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ENGINEERING:

An Illustrated Weekly Journal.

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VOL. CXVII.—No. 3043.] *LONDON: FRIDAY, APRIL 25, 1924.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 5½d.

Aveling & Porter, Ltd.,
ROCHESTER. 1869

Steam Road Rollers & Tractors.

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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS.
See Advertisement page 37.
PATENT WATER-TUBE BOILERS. AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected. Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." —Great Eastern Road, Stratford, E. 15. 1794

GEARS OF EVERY DESCRIPTION.
Spring Grove,
AUTOGEARS (LEEDS), LTD., Hyde Park Road, Leeds. 1743

HEAT INSULATION.
CELITE PRODUCTS CORPORATION,
Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, April 11.

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
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PRESSED STEEL WORK OF ALL KINDS. Od 3382
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Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1864

Spencer-Hopwood & Kirke
PATENT BOILERS. *See page 71, April 18.* 1994
Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

The Glasgow Railway Engineering Company,
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London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES,
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1948

ALL GALVANISED FITTINGS FOR
Wireless Receiving Sets.
FELLOWS BROS., LTD.,
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Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS.
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BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

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Duckham's Patent Suspended
WHIGHING MACHINES—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See illus. Advt. last week, page 15. 1715

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GEORGE RUSSELL & CO., LTD., Motherwell. 1567
Telegrams:—"Cylinders," Birmingham.

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for Water-tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
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SHALLOW DRAFT VESSELS. 1553

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SPECIALISTS IN
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for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

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PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3551
ENGINEERS & BOILER MAKERS.

For Your Repairs or any
SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W. 11.
Est. 1854. 2007

The Mitchell Conveyor and
TRANSPORTER CO., LTD.,
CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS
of
all Classes of HANDLING MACHINERY.
Atlantic House,
45-50, Holborn Viaduct,
London, E.C. 1.
Telegrams: "Micontraco, Cent, London.
Telephone: Holborn 2822. 1713

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For ALLUVIAL GOLD, PLATINUM & TIN, HARBOUR, RIVER & CANAL.—Gravel Dredgers, SCREENS.—DREDGE BUCKETS & Parts, all sizes.
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Telephone: London Wall 3418. 1814

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Hurst, Nelson & Co., Ltd.,
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3483

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CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 8547
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See's Patent Hydro-Pneumatic **Ash Ejector**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

Penningtons, University
TUTORS, 354, Oxford Road, Manchester. Estab. 1876. Enrol now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 1711

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 91.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, } ROW'S PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

IRON & STEEL
Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM - LONDON.
See Advertisement, page 27. 1872

Electric Generating Plant for SALE.
Direct Current.

Two	26 Kw.	105 Volts.	"Howden-B.B.H.
Two	53 ,,	,, ,,	"Brotherhood-Laurence Scott."
Two	100 ,,	440/500 ,,	Gerrett Semi-Portable.
One	120 ,,	110 ,,	"Belliss-Siemens."
One	150 ,,	220 ,,	"Howden-Lane, Dynamo."
Two	200 ,,	,, ,,	"W. H. ALLEN."
Two	200 ,,	,, ,,	"Belliss-Siemens."
One	240 ,,	440/500 ,,	"Belliss-Phœnix Dynamo."
One	375 ,,	250 ,,	"Allen-Westinghouse."
One	400 ,,	240 ,,	"Howden-Siemens."
One	500 ,,	230 ,,	"Howden-B.T.H."
One	500 ,,	230 ,,	"Belliss-B.T.H."
One	500 ,,	500 ,,	Metropolitan Vickers Turbo.
One	600 ,,	500 ,,	"Belliss-Mather & Platt."
One	750 ,,	220 ,,	"Parsons-Crompton" Geared Turbo.
One	1250 ,,	250 ,,	"Belliss" Turbo.

Alternating Current, 3-Phase, 50 Periods.

One	400Kw.	500/550Volts.	"Howden-G.E.C."
One	750 ,,	,, ,,	"Metropolitan Vickers."
One	850 ,,	,, ,,	"Fraser & Chalmers."
Two	1000 ,,	,, ,,	"Metropolitan-Vickers."
One	1000 ,,	3300 ,,	"B.T.H."
Two	1000 ,,	,, ,,	"Metropolitan-Vickers."
One	2000 ,,	500/550 ,,	,, ,,
One	3000 ,,	6600 ,,	"B.T.H."

All above are modern, and condensing plant is available in nearly all cases.
We can also offer several Suction Gas and Diesel Sets, Babcock Boilers up to 30,000 lbs. per hour, and a very large number of motors, generators, Motor-generators, rotary converters, etc.
Enquiries Invited.
THE PHŒNIX ELECTRICAL COMPANY, LTD., 17, OSWALD STREET, GLASGOW. 822

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers, &c., &c. 1586

For Sale, Motor-Driven Air COMPRESSOR, by Bellis & Morcom. 1000 cubic ft. per min. 100 lbs. pressure, with 500 volt D.C. motor.—THE PHŒNIX ELECTRICAL CO., LTD., 17, Oswald Street, Glasgow. D 321

Regent Guillotine Shears and Power Presses
FOR SHEET AND PLATE WORKING.
THE REGENT STREET METAL MACHINE TOOL CO., LTD., REGENT WORKS, WAKEFIELD. 2015

53 HP. Crossley Suction Gas ENGINE, latest design; magneto ignition, variable governing and single flywheel.—HARRY H. GARDAM & CO., LIMITED, Staines. D 243

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 1553

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1316
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 59, April 18. 2402

Traveller Wanted by Firm of Old-established Machine Tool Makers making heavy tools as used by Shipbuilders, etc. Applicants must be experienced in this class of work, and to the right man a Directorship may be acquired. State age, Experience and Salary, in confidence.—Address, D 523, Offices of ENGINEERING.

Works Manager Wanted for Heavy Engineering Works in the Midlands. Age between THIRTY and FORTY.—Address, stating qualifications and salary, D 518, Offices of ENGINEERING.

Cement.—Maxted & Knott, LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest References. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 1838

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2008

Plenty and Son,
LIMITED,
STATIONARY, STEAM AND MARINE ENGINEERS.
NEWBURY, ENGLAND. 1831

WAYGOOD OTIS LIFTS 2130
54 & 55, FETTER LANE, LONDON, E.C.4.
62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

Diesel Engines, 300, 530, 800 and 1,200 B.HP., M.A.N., with or without dynamos; condition as new. About one-third market price; seen London. All spares for above sizes in stock.
HICK DIESEL OIL ENGINES, LTD., 70, Queen Victoria Street, E.C. 4. 2043

Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9235

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
1676
See half-page Advertisement, page 70, April 11.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. B. STROMEYER, M.I.C.E. Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 323, Oxford Road, Manchester. 2108

TENDERS.

THE CARNARVON CORPORATION invite

Tenders for New Roller and

PATHS, &c., for their Swing Bridge at Carnarvon.

Apply for specifications to BOROUGH SURVEYOR, Carnarvon. D 498

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C.2., Invite

Tenders for :—

1.	Vertical Boilers	Fee	10s. 0d.
2.	Steelwork for Bridges ...	,,	7s. 6d.
3.	Points & Crossings	,,	10s. 0d.
4.	Mantles for Lamps	,,	2s. 6d.
5.	Steel Drawbars for Wagons...	,,	2s. 6d.
6.	Linoleum	,,	5s. 0d.
7.	Expanded Metal	,,	2s. 6d.
8.	Cloth, &c.	,,	2s. 6d.
9.	Mild Steel Bars...	,,	2s. 6d.

Tenders are due by Eleven a.m., on 6th May, 1924, Tender forms obtainable at above address. Fees not returnable. D 574

BOMBAY, BARODA & CENTRAL INDIA RAILWAY CO.

The Directors are prepared to receive up to Noon on Friday, 9th May,

Tenders for the Supply of

STEEL MATERIAL (ANGLES, FLATS, PLATES, ETC.).

Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 20/- each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France, Westminster, S.W.1.
23rd April, 1924. D 567

COUNTY BOROUGH OF SOUTHAMPTON.

COAL HANDLING PLANT, BUNKER EXTENSIONS, ETC.

The Corporation invite

Tenders for the Manufacture,

DELIVERY, ERECTION, etc., at their Electricity Works, Western Esplanade, Southampton, of one ROTARY WAGON TIPPLER, one COAL RECEIVING HOPPER, one GRAVITY BUCKET CONVEYOR, one SET of OVERHEAD COAL BUNKERS, forming an extension to the existing Bunkers, together with Coal Chutes, etc.

A Specification may be obtained of the Borough Electrical Engineer at the above-mentioned Works, upon production of the Borough Treasurer's receipt for a deposit of £1 1s.

Deposits will be returned after the Council have dealt with the Tenders to Contractors who have submitted *bona fide* Tenders.

Additional copies of the Specification may be obtained upon payment of 10s. 6d. each, which is not returnable.

Sealed Tenders endorsed "Coal Handling Plant, etc." must be delivered at the Town Clerk's Office by Twelve o'clock at Noon on Monday, 26th May, 1924.

No pledge is given to accept the lowest or any Tender.

R. R. LINTHORNE,
Town Clerk.

23rd April, 1924. D 573

METROPOLITAN WATER BOARD.

SUPPLY AND ERECTION OF FENCING—SHOOTERS HILL PUMPING STATION, KENT.

The Metropolitan Water Board invite

Tenders for the Supply and

ERECTION of approximately 1000 yards WROUGHT IRON FENCING, at their Shooters Hill Works in the Kent District.

Forms of Tender, Specifications and Drawings giving full particulars may be obtained from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, by personal application (Room 155), or upon forwarding a stamped addressed brief envelope.

Tenders must be on the official forms, enclosed in sealed envelopes, and addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1," endorsed "Tender for Fencing, Shooters Hill," and delivered at the offices of the Board not later than 11 a.m. on Tuesday, 29th April, 1924.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C.1.
12th April, 1924. D 509

METROPOLITAN WATER BOARD.

SUPPLY OF LATHES, &c., FOR BOARD'S TESTING SHOP, ROSOMAN STREET, CLERKENWELL, E.C.1.

The Metropolitan Water Board invite

Tenders for the Supply of

LATHES, and other MACHINE TOOLS, for their Testing Shop, Rosoman St., Clerkenwell, E.C.1.

Forms of Tender and Specification giving full particulars may be obtained from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, by personal application (Room 155) or upon forwarding a stamped addressed brief envelope.

Tenders must be on the official forms enclosed in sealed envelopes, and addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1," endorsed "Tender for Lathes, etc." and delivered at the offices of the Board not later than eleven a.m. on Wednesday, 30th April, 1924.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C.1
12th April, 1924. D 510

G. R.

GEORGE COHEN & ARMSTRONG, DISPOSAL CORPORATION.

Offer for Sale by

PUBLIC TENDER.

PLANT and MACHINERY, ROLLING MILLS, MACHINE TOOLS, RAILWAY MATERIAL and MISCELLANEOUS STORES.

at the

SOUTHAMPTON DEPOT.

The Material includes

ROLLING MILLS and SPARES.

Eight Set Rolling Mills in two sets of four rolls 16 in. by 18½ in., 17 in. by 18½ in., 15 in. by 18 in. driven by 400 b.p. slip ring motors, by Robertson and Co.

Six set Rolling Mills in two sets of three rolls 29 in. diameter by 25 in. and 18 in. by 21 in. by Robertson & Co.

Two set Rolling Mills by Robertson & Co., 12 in. by 12 in.

Spare Rolls 18 in. by 20 in.—17 in. by 18 in.—16 in. by 18 in.—15 in. by 18 in.—15 in. by 15 in.—12 in. by 12 in.—24 in. by 12 in.—24 in. by 30 in.—20 in. by 20 in.—20 in. by 24 in.

Three Main driven Gear Wheels for 12 in. Mill.

Brass bearings for 15 in. to 24 in. Mills.

Coupling boxes from 12 in to 24 in. Mills.

Guide bars, breaker blocks, wobblers for 12 in. to 24 in. Mills, etc., and numerous other Spares.

PLANT and MACHINERY.

Seven sets of McDuff Muffle Furnaces.

Nine sets of Annealing Furnaces.

Crucible furnaces by J. Wright, 250 lbs. capacity.

Crucible Lip Axis Tilting Furnaces 18 in. dia. by 2 ft. 6 in., bevel and worm gearing by J. Wright.

Cast Iron Turntables for same.

Heating Furnaces (Greenhouse) by Lancaster and Sons.

Five Centrifugal Pumps by Gwynne & Co., 2 in. inlet.

4 in. Belt driven Vertical Pumps by Evans, 3½ in. ram by 2 in. stroke.

Vertical Well Pumps by Evans.

Taylor & Challen Cutting and Cupping Presses, daylight 7 in. by 7½ in.

14 h.p. Semi-Portable Steam Engine, by Marshall Sons & Co., twin cylinder 9½ in. dia. by 12 in. stroke.

Horizontal Compound Steam Engine, cylinder 9 in. dia. by 14 in. stroke, with portable Steam Boiler by Davey Paxman.

Guillotine Shearing Machine, capacity 2 in. by ¼ in.

Buckton Bar Shearing Machine, blades 14 in., max. capacity 3 in. deep by 3 in. wide.

18 in. double ended Shears by De Brugue.

3 in. double ended disc Punching Machine by De Brugue, capacity 6 in. dia. by 45 in. thick.

60 in. Centrifugal Fans by Keith Blackman.

CRANES and LIFTING APPLIANCES.

3-ton Electric Jib Crane by Stothert & Pitt, 35 ft. jib.

15 cwt. Morris Hand Block.

3 ton Overhead Runway.

MACHINE TOOLS and WOODWORKING MACHINERY.

9 in. centre S.S. & Sc. Lathe.

5½ in. centre Capstan, 14 in. Slotting Machine, Power Grindstone by Buck & Hickman.

30 in. Band Saw by Wilson & Sons.

24 in. and 28 in. Saw Benches by Pickles.

18 in. double spindle Moulding Machine by Robinson & Sons.

ELECTRIC MOTORS AND ELECTRICAL MATERIAL.

Twelve 440 volts 3-phase 50 periods A.C. Motors, from 5 to 60 h.p.

Four 110 volts D.C. ditto, from 1½ to 10 h.p.

One D.C. 250 ditto, 25 h.p.

Megger Testing Sets, 500 volts, 300 amps.

Electro Dynamometers by Weston Electrical Inst.

Four Pyrometers.

Electric Hot Cupboards, Hot Plates, Cookers and Radiators.

Carbon Brushes, Porcelain Connections, Fuses, Fuse Holders and Insulators.

Resistance Coils, Bushes, Tumblers, Switches, 250 volt Electric Lamps, etc.

RAILWAY MATERIAL AND MISCELLANEOUS STORES.

1400 ft. 55 lbs. Crane Rails.

Large quantity of Cast Iron Moulds, Plumbago Crucibles for 123 and 250 lbs. capacity.

Shafting Pulleys, Blocks and Chain Slings, Iron Platform and Rails, 4½ in. to 6 in. Shears, Tube Cutter and Expander, Steel Elevator, Trucks, Telephone Box, 2 in. Steel Wire Rope, Guillotine and Cutter Blades, Iron Ladders, Sheaves for 5 in. and 12 in. Cranes, six Pressure Guages, Scales and Weights, Wire Cutters, Pick Helves and Heads, Shovels, Spanners, Saws (Metal), Screw Drivers, etc.

CLOSING DATE OF TENDER—MAY 15th

NEXT CATALOGUE OF SALE AND FULL INFORMATION FROM

GEORGE COHEN & ARMSTRONG DISPOSAL CORPORATION,
Abbey House, Victoria St., S.W.1.
'Phone: Victoria 9040. Telegrams: "Cohstrong Bowest." D 543

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—

WHEELS AND AXLES, C. and W. disc type.

Tenders due on the 6th May, 1924.

Tender forms obtainable from above. D 565

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of

1000 TYRES for Carriages and Wagons, as per Specification to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for C. & W. Tyres," with name of firm Tendering, to be lodged not later than Noon on Tuesday, the 6th day of May, 1924.

For each specification a fee of 10/- will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By order of the Board,
R. A. NEVILLE,
Managing Director.

237, Gresham House, Old Broad Street, London, E.C.2.
17th April, 1924. D 552

AMERSHAM UNION.

TENDERS FOR BUILDING WORKS ONLY, VIZ:—NEW BOILER HOUSE, ENGINE ROOM AND LAUNDRY BUILDINGS, SANITARY ANNEXE, ETC.

The Guardians are prepared to invite

Tenders, Subject to the

sanction of the Ministry of Health, for the above WORKS at the Amersham Poor Law Institution.

Firms wishing to Tender for the above Building Works in accordance with Bills of Quantities to be supplied, are requested to submit their names to the Guardians' Architect, Mr. ERNEST E. FETCH, A.R.I.B.A., of 5, Broom Road, Teddington, Middlesex, on or before the 5th day of May next, together with a deposit of £2 2s., which sum will be refunded if a *bona fide* Tender is submitted.

W. J. STANDING,
Clerk to the Guardians.

Amersham,
22nd April, 1924. D 559

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of :—

1. ROOFWORK.
2. SPARE PARTS of Carriages and Wagons,

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Roofwork," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 9th May, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of each Specification.

Copies of the drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

23rd April, 1924.
91, Petty France, S.W.1. D 583

BOROUGH OF COLCHESTER.

The Corporation invite

Tenders for Supply, Delivery

and SETTING TO WORK of the following PLANT and EQUIPMENT at their proposed new Power Station at the Hythe, Colchester.

SECTION 1.	20 Ton Electric Travelling Crane.
SECTION 2.	Dry Back Boilers (10,000 lbs. steam per hour) and Superheaters.
SECTION 3.	Water Tube Boilers (10,000 and 20,000 lbs. steam per hour) and Integral Superheaters and Economisers.
SECTION 4.	Coal Conveying and Handling Plant, Wagon Tippler and Weigh Bridge.
SECTION 5.	Steel Chimney and Induced Draught Motor Fans.
SECTION 6.	Turbo Alternators (1250 Kw., 1500 K.V.A.) and Surface Condensing Plant, Pumps, etc.
SECTION 7.	Rotary Converters (1000 Kw. and 250 Kw.) and Transformers.
SECTION 8.	E.H.T. and L.T. A.C. Switchgear, D.C. Switchgear and Cable Connections.
SECTION 9.	Nozzles, Valves and Pipes for Cooling Pond, Motor Pumps for Reservoir, etc.
SECTION 10.	E.H.T. Feeder and Pilot Cables, L.T. Cables and Roadwork.
SECTION 11.	Transformers and Equipment for Sub-Stations.

Persons desiring to Tender must communicate their intention to Mr. W. C. C. HAWTAYNE, of 9, Queen Street Place, London, E.C.4, the Consulting Engineer for the Scheme, on or before Saturday, the 3rd of May, stating clearly the Section or Sections for which they desire to tender.

Specifications and plans will be issued on or about the 15th May to persons who have complied with the above requirement and who, after receiving notice from the Consulting Engineer, send to the undersigned a deposit of Two Pounds in Treasury Notes for each Section required.

The deposits will be returned on receipt of a *bona fide* Tender on or before the prescribed date.

Tenders sealed and endorsed "Electricity Supply, New Generating Station," to be delivered to the undersigned on, or before twelve o'clock Noon, on Monday, 2nd June, 1924.

The Corporation do not bind themselves to accept the lowest or any Tender.

H. C. WANKLYN,
Town Clerk.

Town Hall, Colchester,
April 19th, 1924. D 560

APPOINTMENTS OPEN.

Young Mechanical Engineer,

good technical education, some shop experience. VACANCY in Flour Milling Engineering Department of Manufacturing and Consulting Engineers. Previous experience Flour Milling not necessary.—Address, D 545, Offices of ENGINEERING.

CITY OF CARDIFF EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.

Principal, CHARLES COLES, B.Sc. (Lond.).

The Services of an

Assistant Instructor with

good qualification in Naval Architecture, Experimental Science and Mathematics, are REQUIRED in the Marine Technical Department which includes Marine Engineering and Navigation (B.O.T.) Examinations. Practical Shipyard Experience is desirable.

Commencing salary £300 per annum, subject to the Regulations of the Committee re percentage deduction.

Applications, on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three recent testimonials, should reach the Principal (from whom further particulars may be obtained) not later than May 10th.

The selected candidate, before being appointed, will be required to submit himself for examination by the Authority's Medical Examiner at Cardiff.

JOHN J. JACKSON,
Director of Education,
City Hall, Cardiff.

15th April, 1924. D 537

Works Manager Wanted

by a Firm employing 2000 hands, engaged in the manufacture of chassis and body work for motor vehicles. It is absolutely essential that applicants should have first class experience in modern machinery methods leading to a high standard of accuracy in repetition work, and be possessed of marked ability in shop organisation and control. The position offers a unique opportunity for an energetic "seven-thirty works" man accustomed to controlling men and wrestling with difficulties and quickly see some results from his efforts. Write in the first instance giving full particulars of experience, age, salary required etc.—Address, D568 Offices of ENGINEERING.

The Royal Air Force

REQUIRES ELECTRICIANS, ELECTRICAL FITTERS, POWER STATION TRADESMEN and WIRELESS OPERATORS. Age limits 19 to 30. Pay from 24/6d. to 38/6d per week, on enlistment, and all found. Allowance for wife and children to men 26 and over. —Write, stating age, or call, INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. D 585

Assistant Engineer Required

to take charge of Carriage and Wagon section of C.M.E's drawing office on Railway in South America. Age 27 to 35. Should be good draughtsman with practical shops experience on Railway Carriage and Wagon building, mechanical and technical training, with at least two years in drawing office on Railway carriage and wagon design.—Apply by letter giving full particulars, to FOX & MAYO, Consulting Engineers, 155, Dashwood House, E.C.2. D 562

Commercial Electrical Eng-

INEERS (single men) capable of handling enquiries and orders for A.C. and D.C. machines and large Switchboards. College training and test experience essential, erection experience an advantage. Immediate location Midlands, eventual prospects, foreign service. — Address, D 536, Offices of ENGINEERING, stating age, experience and salary required.

Capable Engineer and Live

Man REQUIRED to supervise the progress of work through shops of General Engineering Works. Man accustomed to accurate production and used to steam preferred. State age and experience, also wages required.—Address, D 540, Offices of ENGINEERING.

Draughtsman, Required for

London Office, with experience of factory buildings and constructional steelwork.—Write, stating age, experience and salary required, L., BOX 1267, SELLS Advertising Offices, Fleet Street, E.C.4. D 566

Draughtsman, Tramway and

Railway Rolling Stock.—Apply (letter only), stating age, experience and salary to The CAR MANAGER, The ENGLISH ELECTRIC Co., Ltd., Box 36, Preston, Lancs. D 503

Leading Draughtsman

REQUIRED for Electric Traction Control Equipments.—Address, stating salary required and experience, D 538, Offices of ENGINEERING.

Draughtsman, Fully Quali-

fied, REQUIRED by Harbour Authority, temporarily, with experience in design of heavy swing bridges.—Write, full particulars as to age, education, training, qualifications, experience, and salary required, BOX F 906, LEE & NIGHTINGALE, Advt. Offices, Liverpool. D 542

CITY OF LIVERPOOL.

STRUCTURAL DRAUGHTSMAN FOR CITY BUILDING SURVEYOR'S DEPARTMENT.

The Health Committee of the Corporation of Liverpool invite

Applications for the Post of

a STRUCTURAL DRAUGHTSMAN in the City Building Surveyor's Office. The duties will comprise the examination and checking of structural steelwork details and calculations, and candidates must have had good technical and shop training and drawing office experience.

Salary will be at the rate of £315 per annum, rising by annual increments of £15 to £360 per annum.

The person appointed will be required to contribute to the Corporation Superannuation Fund. Applications, stating age (which must not exceed 35 years), experience and qualifications, together with copies of not more than three testimonials, are to be sent to the Town Clerk, Municipal Buildings, Dale Street, Liverpool, on or before the 10th May, 1924, endorsed "Structural Draughtsman."

Canvassing of the members of the Council will be regarded as a disqualification.

WALTER MOON,
Town Clerk.

Town Clerk's Office,
Liverpool,
23rd May, 1924. D 571

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THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page* 489.)

On Friday morning, April 11, the members reassembled, with the President, the Duke of Northumberland, in the chair, and after the secretary had read the list of candidates for election and transference, the names were formally approved by the meeting. The first paper of the day was entitled "Further Experimental Work on Diesel Engines," by Engineer-Commander R. Beeman, R.N., of the Engineer-in-Chief's Department of the Admiralty. This paper, which was read in abstract by the author, we are reproducing almost in full, the introductory part appearing on page 559 of our current issue.

Further Experimental Work on Diesel Engines.

The discussion was opened by Sir Robert Dixon, who stated that the paper represented the views of the department of which he was the chief, and it was hoped that the experimental results given would prove of use to marine oil-engine designers generally. It might be of interest to mention the reasons for the experimental laboratory being established. When steam furnished the only propulsive power, the problems of the Navy were similar to those of the Mercantile Marine, so that the Admiralty could utilise the experience of all the engineering firms in the country. The introduction of the oil-engine altered matters, as the requirements of naval oil engines were not the same as those for the merchant service. It looked as if we might be falling behind other countries in high speed Diesel engine design, so in 1918 the Admiralty instituted a laboratory for purposes of research. At first it was at South Kensington, but was later moved to its present position at West Drayton. Engineer-Commander, now Professor, Hawkes, was the first superintendent, and to his energy and ability its success was largely due. He was ably followed by Engineer-Commanders Knott and Tostevin, the latter of whom was now in charge of the Laboratory. The result of the research work had so far fulfilled expectations, and even better things were hoped for in the future. It could safely be said that we were to-day certainly not behind other countries in the design of high-speed oil engines.

Mr. Ruck-Keene referred to the increasing percentage of vessels recently built in Great Britain fitted with oil engines, and stated that the experience of the last thirteen years had brought about considerable improvements in these engines. Shipowners now realised that oil engines were reliable, some were having all new vessels equipped with oil engines and others were converting steam-driven to oil-driven ships. During the last year Lloyd's had approved plans of 126 vessels over 300 ft. in length to be built in the United Kingdom, and of these 33, or 26 per cent., were to be fitted with oil engines. In 1914 Lloyd's required an annual survey of such vessels, but they now were content with surveys at intervals of four, eight and 12 years, as in the case of steamers, with a modified survey every two years. As evidence of progress it might be mentioned that vessels with 6,750 brake horse-power and 9,000 brake horse-power on single shafts were under construction for the Mercantile Marine.

Mr. James Richardson thought that the Admiralty deserved thanks for permitting the data given by the author to be published. The indicator diagrams in the paper showed a greater horse-power developed in a small cylinder than ever before; Figs. 6 and 8 showed excellent combustion and efficiency. In oil engine design the heat stresses were the most important factors to consider, and they could be measured in terms of the B.Th.U. flowing through the walls in a given time. The speaker had found comparisons of engines on this basis a most useful source of information. To give it a numerical value he took the pounds of fuel burnt per hour per square inch of piston area, as a measure of the heat to be contended with. This was not absolutely accurate because of the difference in stroke-bore ratio of different engines, but it was quite accurate enough for all practical purposes. The performances given in the paper, when regarded from the standpoint mentioned, were very remarkable. It might be taken that every type of marine Diesel engine to-day used about 0·2 lb. of fuel per hour per square inch of piston area. The figure might rise to 0·3 lb. on trial, but at sea it was about 0·2 lb. In the large Fairfield-Sulzer engines referred to by Mr. Ruck-Keene 0·38 lb. of oil were burnt per hour per square inch of piston area on trial. The Admiralty experimental engine was using 0·52 lb. under the same conditions, and from these facts the advance in design would be evident.

The Diesel type of engine was necessarily clumsy because of its high initial pressures, which resulted in the metal only being stressed to a reasonable amount for about 15 per cent. of the working time. It would not do to be too optimistic as to the future, but Engineer-Commander Beeman had been perhaps a little too pessimistic in this outlook in the early part of the paper. Diesel engines had only been at sea for 15 years, and the progress since 1909 had been extraordinary considering the circumstances. The first five years were experimental, then came five years of war, and then the post-war slump. Nevertheless cylinder diameters had increased from 15¾ in. to 31½ in. in the passenger vessels now building, the power per cylinder had increased from 60 to over 1,125 brake horse-power, yet the heat factor had only risen from 0·15 lb. to 0·3 lb. If by redesigning, or using special materials, we could work at the heat factor of 0·52 lb. which the Admiralty experiments had indicated as possible, the advance would be enormous.

Mr. L. G. Le Mesurier suggested the use of a Diesel engine for cruising and steam plant for the higher speed condition of war ships. Messrs. Thornycroft had considered such a scheme some years ago but the war put an end to their investigations. The proposal would enable a warship to get away from port at a moment's notice. The author had said that the two-stroke engine was more severely heat stressed than the four stroke, but if engines of the same power were considered it would be obvious that the two-stroke engine had a much smaller cylinder than the other, and owing to the absence of valves, the cylinder head would be a much simpler casting. Seeing that the excellent results of the experimental Diesel engine were only marred by the failure of the original cylinder cover, the importance of simplicity in the design of this item would be obvious. Extensive tests had recently been carried out to determine the temperatures in various parts of the combustion chamber of the Sulzer two-stroke engine, and they were very reassuring. The engine was of the four-cylinder two-cycle marine type with cylinders 23·5 in. diameter and developing normally 1,350 brake horse-power at 100 r.p.m. Thermo-couples were placed at about 30 points at the inner and outer surfaces of the liner, piston and cover, the actual location being 0·02 in. below the surface being tested.

Observations thus made showed that the highest mean temperature recorded was only 630 deg. F., this occurring at the top of the cylinder liner at full power. The maximum temperature in the cylinder cover and piston was 570 deg. F. Many tests were made to investigate the cyclic temperature variations, and these showed the maximum variation at the inner wall to be from 25 deg. F. to 30 deg. F. The duration of the trials of the "Digit" engine had not been mentioned, and it would be interesting to know whether it could run with reliability for long periods under the conditions stated. Taking the power as 443 i.h.p., corresponding to about 332 brake horse-power, the results were clearly a considerable improvement on those of the German four-cycle submarine engines. Many years ago tests were carried out of a Sulzer two-cycle engine with the object of increasing the mean effective pressures. Mr. Le Mesurier showed two indicator cards taken from an experimental engine, of 15-in. bore by 21·7-in. stroke, which showed a mean pressure as high as 304·5 lb. per square inch. The engine when developing this pressure was only running at 100 to 105 r.p.m. For faster running engines, of the submarine type, moderate mean pressures were adopted.

A comparison of this engine with the "Digit" engine, developing 443 i.h.p., with a cylinder 20-in. bore, with a 20-in. stroke, could not be made unless one knew whether the power rating was on the same basis. The results of the experiments, referred to by the author, on aluminium pistons were exceedingly interesting, but they would not have the same importance in heavy oil engines as in the case of light high-speed petrol engines. For engines of large power it was likely that cooled pistons of the cross-head type would be necessary, so that aluminium would not reduce the weight of the reciprocating masses in the same proportion.

Mr. C. S. Lillicrap said that naval constructors were now faced with the problem of Diesel engines for high-powered warships. In naval work flexibility of control was of extreme importance, and that had driven some engineers to consider electric and other methods of propulsion. Mercantile vessels in general made long voyages, but the engines, once started, worked more or less continuously. Naval vessels, on the other hand, generally worked in company, and tactical requirements necessitated frequent changes of speed, stopping, starting, &c. Experience had shown that for this purpose Diesel engine installations were much inferior to steam-powered sets. With regard to high-powered warships, a new factor, of great importance, had been introduced by the Washington Treaty. This Treaty fixed the standard displacement of warships, this displacement being defined as "the total displacement of the ship equipped in all respects ready for sea and war, but excluding fuel and reserve feed water." From this point of view the comparison of weights given by the author in Table I was altogether inadmissible. The increase in deadweight of machinery necessitated some decrease in other features of the design, which practically meant a decrease in armament or in power. It was very unlikely that such a sacrifice would be acceptable, and this emphasised the difficulties of obtaining Diesel engines to compete with steam turbines. Naval architects looked askance at the space required for Diesel engines. The speaker recollected the case of a vessel in which the space required for a 6,000-b.h.p. Diesel installation was practically half that required for the engines and boilers of a 40,000-s.h.p. steam turbine set. Another factor militating against Diesel engines was the relatively high centre of gravity of such installations, and also the enormous weight necessary for bearers as compared with that for steam turbine sets. In the vessel referred to the weight of Diesel engine bearers was of the order of 70 tons as compared with 40 tons for the engines and boilers of the 40,000-h.p. turbine set. Furthermore, with the ever-increasing attention to gunnery, &c., the question of vibration was likely to become of increasing importance, and reciprocating engines were notorious offenders in this respect.

Mr. J. H. Narbeth mentioned that he was at the Admiralty from 1904 to 1914, when the initial problems of the Diesel engine for naval service were tackled. The Department never flinched at the difficulties, and the engineer-in-chief's department were now conducting sane and practical investigations which were of the very highest importance.

Engineer-Commander Beeman, in reply to the discussion, said that he had been asked how long the trials of the "Digit" engine had lasted. They were six-hour trials, and the engine was not cleaned between successive trials. He thought the pressures which had been attained were just beyond the limits of practicability for continuous service. Referring to Mr. Le Mesurier's remarks, the problem of the Admiralty was to get a certain power within given limits of weight and space, and the standpoint of the paper was taken on that basis. Mr. Lillicrap had drawn attention to the requirements of the Washington Treaty, but such a basis was quite artificial, and no one would dare to state with confidence that it would be the same in ten years' time.

The Vibration of Ships.

The next item on the programme was a paper on the vibration of ships, by Mr. H. W. Nicholls. The paper, which was read by the author, was prepared from the results of work carried out at the Royal Naval College, Greenwich, in connection with the

1851 Exhibition Commissioners' Post-Graduate Research Scholarship in Naval Architecture. The objects of the investigation were to identify the causes of vibration in a particular vessel, to ascertain the structural or other changes necessary to obviate the vibration, and to investigate reliable methods of calculating natural frequencies of vibration in ship structures, so that the conditions resulting in undue vibration could be avoided. The methods used were based particularly on the principle that the energy stored in the vessel elastically in the extreme position of its vibration can be equated to the kinetic energy of the vibrating system in its mid position. Different methods of calculation have been compared, the methods differing fundamentally in the items included in the energy balance. The evaluation of the energy quantities was discussed, the method of calculating natural frequencies explained, and the results of calculations given and compared with experimental data obtained from a dynamic model. An important part of the paper related to the effect of the virtual mass of the water vibrating with the vessel, which was shown to be of great importance in the model experiments. Although the effect of the virtual mass might not be so great in the case of a full-size vessel, its influence was believed to be considerable and to be sufficient to explain certain anomalies exposed in the calculations given in the paper. A second section of the paper related to the calculation of natural frequencies of torsional vibrations, and a third section dealt with the chief causes of vibration.

Professor Kriloff, at the invitation of the Chairman, read a long communication describing an alternative method of investigating vibration problems, which communication was handed to the Secretary for inclusion in the Transactions. Professor B. P. Haigh, under whose guidance the work described in Mr. Nicholls' paper was carried out, briefly explained the nature of the investigations, remarking, in conclusion, that it was desirable for the Institution to follow up the beginning made by obtaining further data relating to merchant ships and investigating them on the lines developed by the author. He indicated that simple formulæ of an empirical character were in sight, which it would be possible to apply in a few minutes. Mr. A. P. Cole, who also spoke on the paper, congratulated the author on his work and asked for further information on certain points. He did not like the idea of increasing the virtual mass of the ship to obtain the desired result. The author, in reply, thanked Professor Kriloff for his contribution to the discussion and pointed out, in reply to Mr. Cole's remarks as to the effect of the water on vibration, that the figures given in the paper had been obtained with a small model and were not considered to apply to a full-size ship. The allowance mentioned in the paper had been found necessary to make the results agree with calculations taking into account all the other energy items. He would reply fully in writing to the other points raised in the discussion.

THE TORSION OF SHIPS.

The remaining item on the programme for the morning session was a paper by Mr. G. Vedeler on the torsion of ships. The object of the paper was to show how to calculate the torque in a seaway and the stresses due to the torque and due to the rate of change of torque. In the first section of the paper, the author dealt with the calculation of the static torque and with the effect of rolling and heaving on the dynamic torque. He then developed the necessary formula for calculating the stresses due to the torque and described the verification of the formula by torsion tests on tubes of rectangular section formed from two steel plates riveted together. In a later section, the stresses due to the rate of change of torque along the length of the vessel were discussed, and the author showed that high stresses might be set up in the framing where the rate of change of torque was a maximum. An appendix to the paper gave the detailed calculations for a cargo steamer of 6,000 tons deadweight.

Owing to lack of time, the author read only a brief extract from his paper relating to the stresses in the frames due to the rate of change of torque. Mr. E. V. Telfer, who spoke on the paper, stated that a few years ago an able exposition of the problem of the torsion of ships had been given by Stieghorst in *Schiffbau*. Stieghorst's analysis differed from that of the author, but the former had shown that as long as double-bottoms were employed, trouble must be expected at the corners. In connection with the author's experimental investigations of the twisting of rectangular tubes, the speaker mentioned that some three years ago he had himself made some experiments on the twisting of bars of cruciform section. A solid bar had first been tested and then a bar formed of two "tée" bars, riveted together but having the same modulus as the solid bar. The twist of the riveted bar, for a given torque, had been found to be twice as great as that of the solid bar, showing that the effect of the riveting was of great importance and indicating that theoretical findings could not be applied directly to riveted structures. The speaker inquired what was the magnitude of the torsion likely to be experienced in a ship, remarking that it would seem to be greater than would be predicted from the author's work, assuming a solid section. He finally referred to the work of Griffiths and Taylor (*see* ENGINEERING, vol. civ, pages 652 and 699), in which the problem of the shear stresses in a propeller blade had been investigated by means of soap films, and inquired whether, in the author's opinion, the soap-film method could be used to indicate the distribution of shear stress due to torsion in a complicated structure such as a ship.

After Sir A. Denny had expressed his appreciation of the work described in the paper, the author replied to Mr. Telfer, stating that he had not examined the paper of Stieghorst referred to, but would do so. With regard to the experiments made by Mr. Telfer showing that riveting had a great effect on torsion, the speaker did not think the same results would be obtained with a hollow closed section. The fact that the section was closed made a great difference, and he had not found much effect due to riveting. He did not think it would be possible to employ the soap-film method for investigating the shear stresses in a ship section, because the plate thickness was so small in comparison with the area of section. Finally, he remarked that as his paper was of a theoretical character he would have been glad if people with practical experience had spoken on it. He had endeavoured to make the calculations as simple as possible, but it must be borne in mind that the dynamic calculations were only approximate.

This concluded the programme for the morning session, and after votes of thanks to the authors had been proposed and carried, the meeting adjourned.

THE EFFECT OF WIND AND WAVES ON THE PROPULSION OF SHIPS.

At the afternoon meeting, the chair was again occupied by His Grace the Duke of Northumberland, and the first paper taken was one by Mr. J. L. Kent, giving an account of the effect of weather, &c., on the speed and behaviour of four ships from data obtained by the author during four ocean voyages. The vessels were the Canadian Pacific passenger steamer Montcalm, the Furness-Withy express cargo steamer London Mariner, and two oil tank steamers San Gerardo and San Tirso belonging to the Eagle Oil Transport Company. The paper gave a general description of the observations taken and the manner in which they were obtained, described the wind and waves encountered tracing the effect of the former on the latter, and gave an analysis of the part played by the weather in reducing the ships' speed at various stages of the voyage. Later sections contained an account of the pitching and seaworthiness of the ships under various weather conditions and described the effect of wind, &c., on steering. Finally a summary of the principal factors causing loss of speed at sea was given, these factors including increased resistance due to ocean waves, increased wind resistance on the ship's upper works, decrease in propeller thrust due to loss in propeller efficiency, and increased resistance due to the use of the rudder.

After the main sections of the paper had been rapidly read by the author, the chairman called upon Sir John Biles to open the discussion. Sir John first congratulated the author upon the patience and perseverance he had displayed in recording information under particularly difficult conditions. The speaker regarded the attempt to record the form of the sea throughout the whole of a continuous voyage as almost hopeless and he thought the author must have taken considerable trouble to obtain the record he had given. Pitching observations, the speaker continued, were fairly easy to record but rolling observations were not so simple, since it was necessary to rely upon the horizon which was not always visible—especially in the worst weather conditions. He referred to some cases of pitching in which there was synchronism between the period of the ship and the period of the waves and mentioned that, under these conditions, he had seen green seas going over the bows of a vessel in what appeared to be a dead calm. He enquired if the author had attempted to evaluate the increase of resistance due to the causes mentioned over a whole voyage. If such an average value could be obtained it would be of great value to ship designers who had often to predict a mean speed over a given route. As a rough measure, the speaker added, it was not uncommon for an increase of 25 per cent. to be made in the smooth-water horse-power to obtain the required mean speed over an average voyage, while for the North Atlantic, the increase might amount to 30 per cent. For an 18-knot to 19-knot vessel, the average speed on the Atlantic, all the year round, was about 1 knot less than the best speed in smooth water. He thought, however, that the author would be able to obtain from his observations a more reliable figure than the rough ones which he (the speaker) had mentioned.

The next speaker, Mr. J. Anderson, said while he fully appreciated the value of the paper and the labour involved in its preparation, he had been trying to find to what practical use the data it contained could be applied. The problem of determining the minimum horse-power required to obtain a fixed surface speed at sea, was a particularly difficult one, and in spite of all the work carried out by the author, the speaker was afraid the paper had not provided him with the information he required. There were very great fluctuations in the figures given in the tables and he thought it would still be necessary to fall back on the old method of taking average results for three, six or twelve months' working in order to arrive at the mean speed of a vessel. He noticed that the author had concluded that there were four factors which influenced the loss of speed, but only one or two of these were subject to the control of the naval architect, viz., the wind pressure resulting from the arrangement of the accommodation and the effect of the rudder; the latter, however, would not have much effect on the speed of the vessel. Some years ago, the speaker continued, he had been interested in the problem of stowage of cargo and its effect upon speed in heavy weather, on which subject the author had read a paper. The speaker's firm had tried some exhaustive experiments on the effect of concentrating cargo amidships to prevent pitching in heavy weather, but the results had been entirely disappointing. He was therefore forced to the conclusion that the only method of estimating the power required in excess of still-water conditions was by past experience.

Sir A. Denny, who followed, gave an account of his experiences in the Parisian, in which he was sent to sea some 30 years ago, in order to study the effect of the waves on the ship's structure. He also gained some information as to the influence of the weather on the speed of the vessel, which, he said, would average from 325 to 350 nautical miles a day in fair weather. Actually, the ship only covered 125 nautical miles on the first day out and 120 nautical miles on the second day owing to the exceedingly bad weather experienced. Continuing his remarks, the speaker pointed out that the allowance to be made for increase of power over smooth-water trial conditions varied with the locality of the voyage. On an eastern voyage, an allowance of less than 15 per cent. would suffice, but for the North Atlantic, the average figure, as far as it could be obtained, was not below 30 per cent. while 40 per cent. was probably necessary. The speaker said he had been under the impression that the author was to have carried out some measurements of structural strains of vessels in heavy weather. The Bulkhead Committee had suggested that it would form a valuable research for skilled observers to go to sea

in heavy weather and employ a strain indicator to measure the stresses to which the ship was actually subjected. He enquired whether any suggestion had been made at the National Physical Laboratory that such observations should be carried out. In connection with the loss of speed due to the use of the rudder, the speaker referred to the use of the Sperry gyroscopic compass or "iron quartermaster" which, he said, made a great difference in the steadiness of the course steered and so diminished the loss of power due to the rudder, although that loss was not very serious.

Mr. W. J. Luke, the last speaker in the discussion, asked if the author would look into the figures given in the paper as the pitching periods of the four vessels referred to. The best observations on the Aquitania and Lusitania, he said, gave a pitching period of 8 secs. for those vessels, and he could not therefore understand why, in the case of the smaller vessels, San Gerardo and San Tirso, the pitching periods should be greater, viz., 10·2 secs. and 9·8 secs. respectively. He thought it possible that these figures were erroneous.

After a written communication on the paper by Mr. G. S. Baker had been read by the Secretary, the Chairman called upon the author to reply, and Mr. Kent, in the course of his remarks, referred to the fact that several speakers had asked for a definite figure for the increase of power necessary to give a uniform speed in bad weather. This, however, was not the main object of the paper, which was to show how the losses were split up. He agreed with Mr. Anderson that experience was the best guide as to the power required, and if data from similar voyages of the same class of vessel over a number of years were available, they would provide the most reliable information. He thought that the strain observations referred to by Sir A. Denny should certainly be made, and in answer to Mr. Luke, explained that the figures for pitching periods given in the paper were obtained from continuously recorded diagrams. He would examine the records again to make quite sure of the figures, but he thought it possible that the long periods obtained might be accounted for by the fact that the two vessels referred to were oil-tank steamers. The figure given by Mr. Luke for the pitching period of the Aquitania, the speaker remarked in conclusion, was in good agreement with one which he had himself obtained while passing that vessel, viz., 7·6 seconds.

At the conclusion of Mr. Kent's remarks the chairman, who had to keep another appointment, requested Sir A. Denny to take the chair for the remainder of the meeting. Before doing so, however, Sir A. Denny proposed a vote of thanks to His Grace the Duke of Northumberland for having presided at the meetings. This was carried with acclamation, and, after the Duke had briefly replied, Sir A. Denny took the chair.

Skin Friction and Ship Resistance.

The remainder of the meeting was occupied with the reading and discussion of three papers on subjects relating to the resistance of ships. The first of these papers, by Dr. T. E. Stanton and Miss D. Marshall, dealt with the effect of length on the skin friction of flat surfaces, and was read by the first-mentioned author. We hope to reprint the paper at a later date, but we may now explain that it described an investigation of skin friction made on a flat steel plate, 16 ft. long, 6 in. wide and 0·05 in. thick, suspended in the longitudinal axis of a 3-ft. square wind channel at the National Physical Laboratory. With a wind speed of 30 ft. per second in the channel, a large number of Pitot tube readings of the air velocity were taken at various distances from the surface of the plate and at different positions along its length. The conclusions drawn from an examination of the readings obtained in this way were that skin friction cannot be taken to be dependent entirely upon the relative velocity of the surface and the fluid in its immediate vicinity, unless accompanied by some mechanism by means of which the particles of fluid are supplied to the surface at a rate which increases as the distance from the leading edge. Such a mechanism, the authors stated, was in agreement with the result of recent investigations, which pointed to the existence of a coefficient of eddy viscosity increasing in value with the lateral extent of the disturbed motion. The result of this action was that the frictional wake might be regarded as having little or no effect on skin friction. It was further concluded from the results given in the paper, that, in the experimental study of the friction of rectangular surfaces which are relatively long in the direction of the flow, the effect of the lateral dimensions of the surface on the mean intensity of friction could not be neglected, and in all investigations of the effect of dimensions on the resistance, strict geometrical similarity in the models was desirable.

The next paper, entitled "Skin-Friction Resistance and Law of Comparison," by Mr. A. Shigemitsu, was taken as read in the absence of the author. The paper gave an account of an analysis by the author of experimental data obtained by Dr. F. Gebers of the Vienna Tank, and the resistances calculated from the newly established formulæ resulting from this analysis were stated to be in better agreement with measured resistances than were those determined by Dr. Gebers' own formula. The author's results practically coincided with those of R. E. Froude for low speeds in the region of Froude's coefficient O. The new analysis was based on a principle analogous to that used in analysing the flow of water in pipes, and, in the author's view, its results might be applied more safely to the calculation of the skin-friction resistances of ships than the methods ordinary employed. He expressed the hope, however, that his work might be taken as the basis of further research on this important problem in naval architecture.

The last paper on the programme, by Mr. J. Tutin, dealing with the analysis of ship resistance, does not lend itself to the preparation of a useful abstract, but we may remark that the treatment of the problem dealt with, viz., the specification of form, the interpretation of plank experiments, resolved surface, form resistance, the fundamentals of wave resistance, and the theory of interference, was thought by the author to be substantially new.

The joint discussion of the three papers, which followed the reading of Mr. Tutin's paper, was opened by the reading by the Secretary of a communication from Mr. G. S. Baker containing comments and criticisms on each of the papers. Mr. M. P. Payne expressed surprise that there was practically no deviation from a straight line in the diagram in Dr. Stanton's and Miss Marshall's paper showing the variation in total friction with the length of the plate. From experiments on longer planks he would have expected to find a decline in the friction along the length of the plate from the leading edge to the trailing edge. He thanked the authors, however, for calling attention to the effect of width. Referring to Mr. Shigemitsu's paper, the speaker said he had applied Geber's expressions to various warships, and had found a decrease in the effective horse-power due to skin friction, and although he had not yet had time to apply the author's formula to those cases, he imagined the effective horse-power would be appreciably greater than would be obtained by the usual methods. He had not yet been able to give much attention to Mr. Tutin's paper, and although he sympathised with its object he did not agree with it in all respects.

Professor J. J. Welch, who continued the discussion, said he was somewhat disturbed by the straight-line diagram for skin friction in Dr. Stanton's and Miss Marshall's paper, since Froude's diagram gave a curve; but he had no doubt that our knowledge of the subject would be increased when the work undertaken by the Institution had been carried out. Mr. Tutin's paper, the speaker continued, dealt with a large number of matters affecting ship resistance, some of which gave rise to differences of opinion. One of the author's objects, however, was to have his ideas discussed, and he had been successful in that respect. The speaker thought Mr. Tutin's idea that certain resistances depending upon the form concerned might be related in the form constants was a reasonable one, but whether this was possible or not would have to be answered by those dealing with research in these matters. He also expressed agreement with the author's suggestion that, for ordinary purposes, it was not necessary to calculate the area of the wetted surface by expansion in both directions, and with his views on the subject of interference, which the speaker explained at some length.

The next speaker, Mr. W. G. A. Perring, referred to Dr. Stanton's and Miss Marshall's paper, pointing out that as it dealt with the effect of length, the experiments should be extended to plates of other lengths. He was somewhat puzzled at the peculiar shape of the curves in the paper showing the loss of momentum in the air. The shape, he thought, could not be explained by loss of momentum outside the plate, and he suggested that it was due to eddies circulating round. He enquired of Dr. Stanton as to the shape of the ends of the plate used, and also asked what would be the effect of rounding off the corners of the section. The speaker also commented on the papers of Messrs. Shigemitsu and Tutin, but, as time was pressing, said he would contribute the remainder of his remarks in writing.

Professor P. Hillhouse found Dr. Stanton's and Miss Marshall's paper extremely interesting, but was surprised to find the old idea that skin friction was reduced as the length increased was not borne out. He had understood Dr. Stanton to say, however, that if the experiments had been carried to greater lengths, the diminution would have been found. The speaker thought the attack on the P × L theory of wave-making resistance in Mr. Tutin's paper was based upon a misapprehension, and added that he had prepared a simple explanation of that theory which he would forward to the Secretary.

Mr. Lancaster read part of a communication expressing appreciation of Mr. Tutin's paper and commenting on a few points, and Mr. J. L. Kent, who followed, gave a brief explanation of the P × L theory, which he thought Mr. Tutin had misunderstood. Mr. E. V. Telfer also criticised several points in Mr. Tutin's paper.

This completed the discussion on the three papers, and Dr. Stanton then replied briefly, owing to the lateness of the hour, to the comments on the paper of which he was joint author with Miss Marshall. The main criticism of the paper, he said, had been to the effect that the frictional resistance remained constant over the length of the plate. This, however, merely meant that they had worked on a horizontal portion of the curve connecting R/v^2 with *vl*. With regard to the shape of the curves referred to by Mr. Perring, the speaker had at first thought the effect to be due to the suspension wires. That, however, was not the case, and Mr. Perring's suggested explanation might be correct. The ends of the plate were filed to sharp knife edges, but the plates themselves were only $\frac{1}{20}$-in. in thickness. He noted that Mr. Perring was anxious for experiments to be carried out on longer plates, but pointed out that the objection to this was the very heavy labour involved in the work. Mr. Tutin, after calling attention to a discrepancy in one of the equations in Mr. Shigemitsu's paper, replied briefly to the criticisms on his own paper, concluding his remarks by expressing the view that there was an inconsistency in the P × L theory.

The Chairman then proposed a vote of thanks to the authors of the papers, which was duly carried, and the proceedings concluded with a vote of thanks to the Secretary and staff of the Institution, proposed by Mr. W. J. Luke and briefly responded to by the Secretary.

The Late Mr. August Jegher.—We regret to record the death in Zurich on February 13, in his eighty-first year, of Mr. August Jegher, a distinguished engineer, for many years editor of our contemporary, the *Schweizerische Bauzeitung*. Jegher was born in Trieste, where his father, a clergyman's son from the Grisons, Switzerland, had settled; his mother was French, and the boy early learnt to speak German, French and Italian. Educated at Weinheim, north of Heidelberg, he went to the Zürich Polytechnikum, but did not take his diploma, because he was one of the 300 students who left the college in 1864 as a protest against certain administrative rules. After a few years of activity in Austria-Hungary as a railway engineer, he returned to Switzerland where he was mainly interested in the re-organisation of the Polytechnikum and was one of the experts of the Commission on the utilisation of hydro-electric power in Switzerland. In 1898 he succeeded his old friend, A. Waldner, as editor of the *Schweizerische Bauzeitung* which had grown out of the *Eisenbahn* founded by Waldner in 1879 as organ of the Zurich Polytechnikum. Jegher remained editor till a year ago, when his son, stepped into his place; but he continued to attend regularly at the office until his health began to fail.

THE ACCURATE DETERMINATION OF THE HARDNESS OF METALS.

AN investigation of this type is impeded at the outset by the entire lack of any comprehensive definition of the term "hardness." Although several definitions have been proposed, they are recognised as being incomplete, and even the possibility of one that is comprehensive seems somewhat remote, for as Dr. Unwin has said "Apparently physicists doubt whether there is a definable quality of hardness."* It would appear also that general opinion deprecates the introduction of new methods which depend for their working on doubtful or fresh hypotheses, and give numerals which are difficult to correlate with those given by present methods. In these circumstances, it follows that attention should be directed rather to the improvement and simplification of existing methods, of which some form of plastic indentation test, such as that introduced by Brinell, is, without doubt, by far the most widely accepted and generally recognised. It is for these reasons that the Brinell test has been the subject of the present investigation, the object in view being the design of a method of testing which yields Brinell hardness numerals of a thoroughly reliable order, free from the irregularities to which the Brinell test is exposed when carried out in the ordinary way.

The causes of the irregularities are so well known as to need no more than a summary :—

1. Inertia and momentum caused by lifting the load and applying it too rapidly.
2. Variable duration of the load.
3. Deformation of the steel ball or indenter.

Fig. 1.

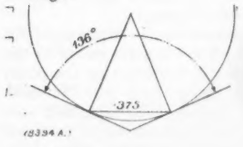
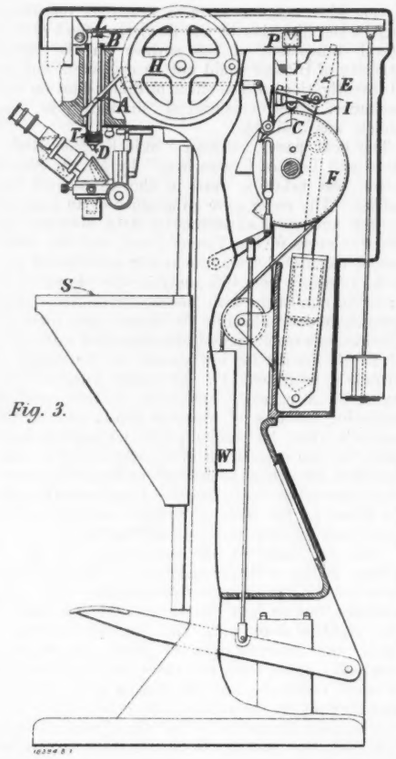


Fig. 2.

4. Difference in deformation of the materials tested. On a given homogeneous material different numerals result from different loads (*i.e.*, different amounts of deformation) due to geometrical dissimilarity between ball impressions of different sizes.

Fig. 3.



This, of course, is most evident on hard materials, it being generally agreed that the figures are unreliable above 600, although some authorities put this at an even lower figure.

5. Errors in measurement.

In the machine described below provision is made for the elimination of these irregularities as follows :

1 and 2. The load is lowered on to the specimen, being applied very slowly and at a diminishing rate. This application and the removal after a predetermined interval are controlled entirely automatically. Inertia and variable duration of the load are thus eliminated.

3. The indenter is a diamond which is incomparably harder than any steel or other metal. It follows, therefore, that deformation of the indenter will be negligible.

4. The diamond is cut to the form of a square based pyramid. It will be seen that this must yield impressions which are geometrically similar and must therefore, within wide limits of size, give comparable results. A similar effect is, of course, obtainable with a cone, but on certain materials it will be found that all circular impressions are both difficult and uncertain to read owing to the lack of definition which occurs at the extreme edge of the impressions. This difficulty does not arise when using a pyramid, the impressions of which are measured across the diagonal corners.

It has been generally advocated that all ball impressions should, if possible, be within the range 0·25 to 0·5 of the diameter of the ball and, accepting the mean of these (*i.e.*, 0·375) as the ideal, the equivalent angularity of impression was taken as standard for the pyramid.

It will be seen from Fig. 1 on this page, that the angle is 136 degrees, and it was found that the hardness numerals obtained with such a pyramid are equivalent to those resulting from ball impressions of the ideal size. Hardness is calculated as $\frac{\text{Load}}{\text{Pyramidal area}}$

5. The measurements of the impressions are taken by means of a specially constructed micrometer ocular, which is fitted with knife edges instead of the usual hair lines, thus reducing eyestrain. The readings are taken entirely from actual figures shown at the side of the ocular, so rendering impossible any errors due to the miscounting of divisions on a small scale.

A machine designed to embody the whole of the above-mentioned points has been produced by Messrs. Vickers, Limited, and is illustrated in Figs. 3, 4 and 5. It is so arranged that after adjustment of the specimen under the diamond, it is only necessary to operate a starting handle and the load is applied and removed entirely automatically. On lowering the stage, the microscope may be swung into a position immediately over the impression.

The impression appears as a dark square on a light ground, and measurements are taken between

FIG. 4.

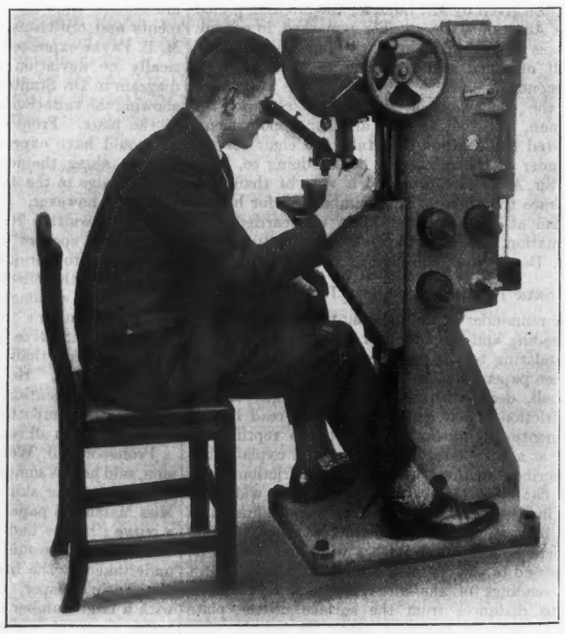


FIG. 5.

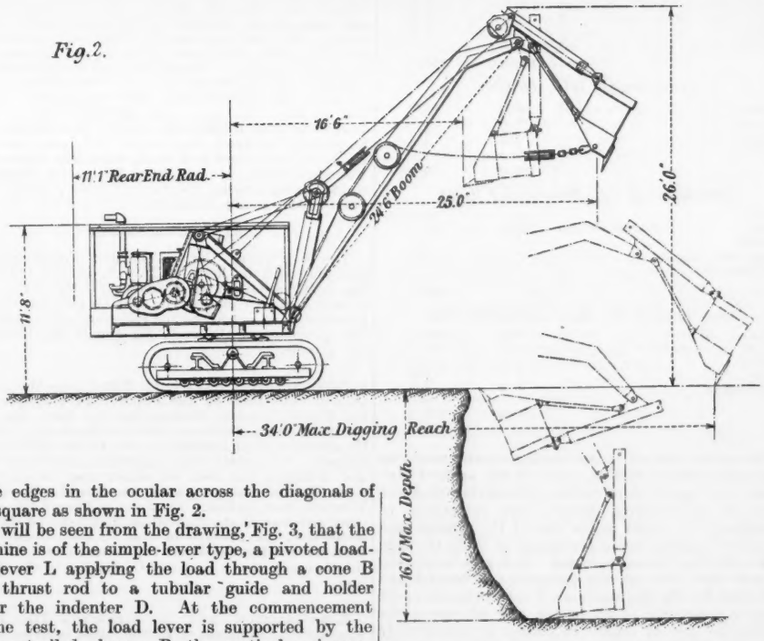
* Proceedings of the Institution of Mechanical Engineers. 1918. Part 2, page 429.

TRENCH PULL SHOVEL.

CONSTRUCTED BY THE NORTHWEST ENGINEERING COMPANY, CHICAGO, ILL.

FIG. 1.

Fig. 2.



knife edges in the ocular across the diagonals of the square as shown in Fig. 2.

It will be seen from the drawing, Fig. 3, that the machine is of the simple-lever type, a pivoted loading lever L applying the load through a cone B and thrust rod to a tubular guide and holder T for the indenter D. At the commencement of the test, the load lever is supported by the cam-controlled plunger P, the vertical reciprocation of which therefore applies and removes the load. In order to carry out a test, the microscope is swung out of position and the specimen is placed upon the stage S, which may be raised by rotation of the handwheel H, operating through bevel wheels and a screw; by this means the specimen is adjusted to be just clear of the diamond. The cam C, controlling the plunger, is mounted on a drum F, and when the starting handle A is pressed, both are rotated by the motor weight W. The movement of the cam at first lowers the plunger, thus applying the test load to the specimen; further rotation raises the plunger and removes the load, the whole operation being completed in 90 degrees rotation of the cam. The speed of rotation is determined by a piston and oil dashpot, the rate of the displacement of the oil being regulated by an adjustable control valve. In the upper end of the plunger is a rubber pad, which, engaging with a cone mounted in the beam, ensures a very slow and diminishing rate of application of the last portion of the load. The valve is set so that 30 seconds are occupied in the application and duration of the load, and the cam is so designed that, of this period, the application occupies 20 seconds and the duration a minimum of 10 seconds.

Visible and aural indication is given at the end of the test by the indicator I, which clicks into the "Finish" position. Depression of the foot pedal returns the cam, drum, weight and piston to their original positions, this movement being facilitated by the opening of a non-return valve in the piston. A tripping piece E meantime supports the beam and drops out as soon as the machine has been re-loaded.

The measuring microscope is of the angular type, mounted on a hinged bracket which is locked into the correct position by a catch. The illumination is vertical, and is obtained from a lamp and condenser mounted on the microscope itself. Accumulators in the base of the machine provide the necessary current for the lamp.

THE NORTHWEST TRENCH PULL SHOVEL.

A GREAT deal of ingenuity has been brought to bear in America in recent years upon the development of excavating machinery of various kinds, and in no direction more so than upon plant specially intended for trench and sewer work. For work of this class the machine which for long we have called the steam navvy—nowadays, as a matter of fact, not always steam-operated—is rather more accurately termed in the United States a power shovel. The action of this machine is approximately of a shovelling nature, though to secure great capacity a bucket is used, and the bulk of the material loads into this on the vertical lift rather than on the forward dig or push. This affects the machine in several ways, making it most effective when working into a bank in front of it and dumping alongside within a certain range of levels. The machine is also effective for trench work, in which it stands at a higher level than the bottom of the excavation, and, provided that it has a firm platform, can work with ease to considerable depths, delivering the material conveniently alongside at ground level. In work of this class, however, the shovel is at a disadvantage as it has to move forward over the ground in which the trench has been dug. This necessitates the provision of timber-balk platforms spanning the trench, limiting the freedom of movement of the machine and entailing a large amount of labour for re-arrangement whenever a move forward or back has to be made.

It was to remove the limitations and expense thus imposed that the trench excavator, working away from its work, was developed. This machine does not have to straddle the trench, but stands on firm ground ahead of the work through which the trench has to be dug. In this respect it has a considerable advantage over the shovel, and much care has been devoted to bringing this type of plant to a high state of mobility and general perfection. This class of machine, however, is again at a disadvantage in that it is a single-purpose appliance and a somewhat expensive one at that. For contractors who engage only intermittently in trench digging, but have constant general excavation work to do, such a machine is for much of the time idle plant carrying heavy charges. To meet the demand for a more versatile machine, capable of more continuous employment, attention was turned to the dragline excavator, and this has been used to a considerable extent on trench work. Like the foregoing machine, it works on solid ground ahead of its trench. It can be made mobile over all classes of land which a caterpillar-fitted machine can traverse, and can be easily manœuvred. It is adaptable to a large range of excavating work, ditching and filling, and so on, and can therefore be economically and constantly employed; but for trench work it has the disadvantage that even with highly skilled manipulation it is impossible to make a clean, narrow cut, though in stiff clay it is feasible to keep the unnecessary excavation down to moderate limits. The dragline machine, however has the great advantage from the contractor's point of view of being convertible. By simple substitutions the machine can be changed into a power shovel, a grab excavator, or it can be used as a simple crane. For this range of work the first cost of the machine is lower than for any other of similar service.

The most recent development in this class of appliance combines the greater power of the shovel with many of the advantages of the dragline. Several machines of the new type have appeared in the course of the past year—among the first, and now certainly one of the most highly developed, being the "Northwest" machine, illustrated in Figs. 1 and 2 on this page. This class of appliance is known as the trench-pull shovel, or trench hoe, and the example illustrated is manufactured by the Northwest Engineering Company, 28 East Jackson Boulevard, Chicago, Ill., U.S.A. This, shovel, as will be seen from the diagram, instead of crowding the digger bucket into the soil ahead of it digs a following trench, the bucket being pulled towards the machine instead of thrust away from it. This enables the appliance to travel ahead on firm ground without necessitating the laying down of timber-platform work, or running the risk of caving due to the overloading of the trench sides. The digger is under much better control than the dragline machine, and the cutting action is much cleaner, so that a deep trench with well-cut sides results, as will be clear from the view given in Fig. 1. At the same time, the cut results in a practically vertical face, so that the machine is much better able to dig up to obstacles than excavators embodying the usual inclined ladder bucket gear, or, of course, the dragline. In addition the design lends itself well to conversion, and the provision of alternate booms enables the machine to be employed on dragline work or ordinary power shovelling. The change can be accomplished in a few hours.

The Northwest Engineering Company's machine is made in sizes capable of dumping at clear heights above ground of 8 ft., 11 ft., and 14 ft. The operation is

accomplished by luffing, and the difference in radius at the beginning of the operation and at the end is 8 ft. 6 in. The maximum height of the boom for the highest dump is 26 ft. above ground level. The greatest depth that can be dug is 16 ft., the width across the side of bucket teeth varying from 24 in. to 48 in. in different models of buckets. In this respect the machine has a great advantage over the excavator, even when the latter is adapted for cutting a limited range of widths, as some are, by the addition of side cutters. The Northwest machine can be supplied with one of three buckets, 24 in., 33 in. or 42 in., and three standard degrees of flare can be adopted for the side teeth. Thus there are available nine different widths to choose from, and, the teeth being bolted on, the user can obtain a variation of at least 6 in. with the same bucket at small expense. The three sizes of bucket are respectively $\frac{3}{4}$, 1, and $1\frac{1}{4}$ cubic yards.

The machine is built with a petrol engine of 60/70 h.p. and with caterpillar tracks, with independent control for steering. The shovel arm, or "dipper stick," is not run in and out on the main boom, but is hinged at the extremity of the latter. By means of tackle attached to the end of the bucket boom and a second set connected with the bucket itself, the shovel can be swung away from and drawn towards the machine. The depth of the cut made is regulated by the angle to which the main boom can be conveniently lowered and the tackle operated. The maximum digging reach is 34 ft. The machine is steered, controlled and operated by one man, and will pile on spoil banks as quickly and easily as the ordinary shovel, but is not suitable for dumping into wagons for reasons which will be obvious from what we have said above.

The trench-pull shovel has not the same capacity as the ordinary power shovel in very hard material. In softer material liable to cave in of itself if high walls are left vertical, as by a trench excavator, they have to be protected by timber lining and strutting, since the machine cannot finish to a batter, the cut being parallel from top to bottom. Here the trench-pull shovel shows an advantage, as it can be controlled to finish to stepped or approximately sloped sides as necessary.

The trench-pull shovel can, after completing its task, leave the job unaided and load itself on a flat railway wagon, without any dismantling being necessary. On arrival at its destination the machine is again at once ready for work.

SUBTERRANEAN COLLAPSE ON THE CITY AND SOUTH LONDON TUBE.

Shortly after five o'clock in the afternoon of November 27 of last year, a subsidence took place at Newington Causeway. Some 40 ft. below the roadway at the place of the occurrence the work in connection with the widening of the City and South London Railway was in progress at night, and temporary joints between the old and new tubes were made every day before the recommencement of the traffic. One of the temporary joints failed. It was at a position roughly 130 yards south of Borough station in the north bound tunnel. The collapse took place on the passage of a train, of which the locomotive struck a portion of the timber and dislodged it, and some 500 cubic yards (650 tons) of coarse gravel and sand fell in to the tunnel, completely blocking it in about 15 minutes. A crater-like cavity, 45 ft. diameter and 15 ft. deep, was caused below the surface of Newington Causeway, and thus support was withdrawn from the electric power and telephone cables and gas and water mains. Escaping gas filled the cavity and by some unascertainable means a violent explosion was caused at 6.5 p.m., that is, about 50 minutes after the failure of the joint in the tube took place. Later a water main collapsed and caused the flooding of the cavity and the extinction of the fire.

An inquiry was held by Lieut.-Col. A. H. L. Mount, whose report has now been published. No one was injured and the train was not derailed, but the driver, with great presence of mind, drew it off into Borough station, where the passengers left the tube with little or no knowledge of the happenings which preceded the explosion. Some water had been observed in the neighbourhood of the occurrence, but only in small quantities and not such as to occasion any thoughts of danger by the staff.

Lieut.-Col. Mount found that the trouble was caused by a depression on the top of the clay at the place in question, and stated that gravel could only have been missed in driving the original tunnel by some few feet. Misjudgment of the importance of the presence of water was in the main due to the impression that work was receding from, instead of approaching, a spot where there was anticipations of weakness, from what had been observed in constructing the original tunnel. The combination of insufficient cover of homogeneous clay under the water-bearing gravel, the consequent presence of water, and the vibration caused by passing trains caused the collapse, and the thickness and bearing of the boards was not sufficient to withstand the excessive pressure. In fairness it was admitted that much of the timbering remained in place after the occurrence. The line was later completely closed, an action which Lieut.-Col. Mount thought a wise one, and in his report he stated that, as far as possible, wherever extensive operations of the same character were undertaken in close proximity to water-bearing strata they should not be interrupted by the running of traffic.

BREAKDOWNS OF ELECTRICAL MACHINERY.

In accordance with their annual custom, the Vulcan and General Boiler Insurance Company, Limited, publish in their quarterly journal *Vulcan* an analysis of breakdowns of electrical machinery insured with the company. The following tables relate to the year 1923, and give the items primarily responsible, together with the relative frequency, and the expense of the breakdowns arising from them. It is pointed out that with direct-current plant the armatures of motors and generators in each case head the list. Not only as regards the percentages of breakdowns, but also as regards percentages of cost.

Description of Parts which Failed.	Percentage Number of Breakdowns.	Percentage Cost of Breakdowns.
Breakdowns of D.C. Motors.		
Armatures	48·4	65·2
Field Coils	15·6	15·3
Starters	17·8	6·1
Commutators	11·7	9·2
Brush Gear	2·3	0·4
Shafts	0·8	1·4
Miscellaneous	3·4	2·4
	100·0	100·0
Breakdowns of D.C. Dynamos.		
Armatures	58·0	61·3
Commutators	18·5	22·2
Field Coils	14·3	13·9
Miscellaneous	9·2	2·6
	100·0	100·0
Breakdowns of A.C. Motors (Slip Ring).		
Stators	27·8	49·9
Rotors	35·4	38·1
Starters	21·7	6·1
Brush Gear	6·1	1·3
Miscellaneous	9·0	4·6
	100·0	100·0
Breakdowns of A.C. Motors (Squirrel Cage).		
Stators	68·3	80·9
Rotors	14·7	11·9
Starters	9·5	2·8
Shafts	1·2	1·5
Miscellaneous	6·3	2·9
	100·0	100·0

The tables relating to alternating-current machines conclusively show that the rotor of the squirrel cage motor is of much more robust construction than the rotor of the slip-ring motor. The percentage of breakdowns of rotors in the case of the squirrel-cage motor is 14, as against a percentage of 35 in the case of the slip ring induction motor. It is also interesting to note that although the percentage of breakdowns to stators for slip-ring machines is only 28 as compared with a percentage of 35 in the case of rotors, the percentage cost of repairs to stators is considerably in excess of the percentage cost of the repairs to rotors. This is in all probability accounted for by the fact that in a very large number of cases the breakdowns to stators necessitated the complete rewinding of the stator, whereas frequently the rotor repairs have been of a minor character.

Fluxes and Slags in Metal Melting and Working.—A general discussion on this subject is to be held on Monday, the 28th inst., by the Faraday Society and the Institute of Metals, with the co-operation of the British Non-Ferrous Metals Research Association and the Institute of British Foundrymen. The meeting will be held from 3 p.m. to 7 p.m., with an interval for tea, at the Institution of Mechanical Engineers, Storey's Gate, S.W. 1. A general introduction will be given by Professor C. H Desch, and there is a programme of some 14 papers intended to initiate discussion on the various aspects of the subject. The papers deal primarily with the uses of fluxes and slags in the smelting and refining of the non-ferrous metals, but there will be one section dealing with fluxing problems in arc and oxy-acetylene welding. The subject of slag inclusions will also be dealt with. A copy of the complete programme may be obtained from the Secretary of the Faraday Society, 10, Essex-street, London, W.C. 2.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Most of the large steel and engineering works resumed operations to-day after a setdown varying from two to five days. Order books indicate that from the standpoint of production in the finished sections increased activity may be looked for. Orders taken directly or indirectly on railway account have been steadily in the ascendant for some months past, both in respect of home and colonial requirements, and to a lesser extent, on foreign trading account. Output of locomotive parts particularly of buffer springs, axles, and tyres has risen much beyond the average level of pre-war years, and has resulted in a greatly increased consumption of supplies from forges, foundries and rolling mills. Motor-car steel has for several months also been a steadily improving line, consignments of castings, stampings and machinery parts sent from this district to automobile engineering centres inland having become a prominent feature of local trading conditions. Owing mainly to exceptional pressure on engineering plant resulting from the enlarged demands experienced in the railway and automobile departments, the overhauling and repair of plant which is customary during the Easter holiday season has been conducted under difficulties, but is now complete. The latest reports received this week from several of the leading engineering establishments in South Yorkshire provide further confirmations of the fact that though output has steadily risen, profits have been reduced almost to vanishing point owing to the exceptionally keen competition of an international character under which business has been taken. Consistent improvement is shown in the tool trades. A steady demand is reported on overseas account for files and various kinds of saws, while garden implements and mining and quarrying tools are going away more freely to provincial distributors.

South Yorkshire Coal Trade.—The holiday set-down at the pits has tended to emphasise the universal shortage of supplies, notably in the best qualities of industrial fuel. The whole output of steam hards is absorbed on contract account, despite a slight falling off of shipments. Cobbles and nuts are strong with a rising tendency, and users report difficulty in obtaining better quality slacks. The coke shortage is holding up operations in several of the steel-producing sections. House coal is easier so far as the current demand is concerned, but collieries and merchants still have considerable arrears to wipe off. Quotations: Best handpicked branch, 36*s.* to 39*s.*; Barnsley best Silkstone, 34*s.* to 36*s.*; Derbyshire best brights, 31*s.* to 35*s.*; Derbyshire best house, 27*s.* to 29*s.*; Derbyshire best large nuts, 27*s.* to 28*s.*; Derbyshire best small nuts, 20*s.* 6*d.* to 23*s.*; Yorkshire hards, 27*s.* to 30*s.*; Derbyshire hards, 25*s.* to 28*s.*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

The Engineers' Club.—The first annual dinner of this club will be held on May 6, at the Connaught Rooms, Great Queen-street, as owing to the large number of members and guests who will be present, the club premises could not afford the necessary accommodation. The president of the club, Sir Joseph W. Isherwood, will preside.

British Empire Exhibition Honours.—We are glad to announce that on the occasion of the opening of the Exhibition, last Wednesday, the King has made Mr. Evan Owen Williams, the chief engineer, a Knight Commander, Civil Division, of the Order of the British Empire. Among the other important works with which Mr. Williams has been connected may be mentioned Bush House, Aldwych, and the Phœnix Works and Wharves, Port Talbot. Mr. John William Simpson, the chief architect of the Exhibition, has received the same distinction. A Peerage of the United Kingdom has been conferred on Sir James Stevenson, Bart., G.C.M.G., the chairman of the Standing Committee of the Exhibition.

Refrigeration and Engineering.—The Fourth International Congress of Refrigeration is to be held in London from June 16 to 21, under the presidency of Sir Gordon H. Campbell. Visits will be paid to refrigerating establishments and to other places of interest, such as the National Physical Laboratory, Teddington, the Port of London Docks, the ports of Bristol, Southampton, Liverpool and Manchester, to which the railway companies are granting a free Congress trip; the leading shipping companies are entertaining the members on vessels in dock. Particulars may be obtained on application to Mr. J. Raymond, Hon. Secretary General, Fourth International Congress of Refrigeration, Weavers' Hall, 22, Basinghall-street, London, E.C. 2.

Walvis Bay to be Linked up with Rhodesia.—A proposal from a South African commercial source has been laid before the Rhodesian Government for the early construction of a railway linking Walvis Bay with the Rhodesian system. The *Bulawayo Chronicle* suggests a junction at Plumtree, and says that if the Bechuanaland Protectorate becomes part of the Union, the present railway to that point would probably be taken over by the Union system. The journal points out the necessity of satisfactory preliminary arrangements with the existing Rhodesian railway companies, notably if as is now suggested, the Union while extending its system to the Limpopo were by agreement with Rhodesia to extend the railway to join the present terminus at West Nicholson.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The market reopened to-day after the holidays, but, as is usual in Easter week business was extremely quiet. A feeling, however, prevails that resumption of activity will not be long delayed, as the comparative cheapness of Cleveland pig-iron is attracting the attention of iron consumers at home and abroad. Home demand continues quiet, but the somewhat considerable expansion of export business is gratifying. Continental producers are experiencing great difficulty in competing with makers here, and sales of Cleveland pig-iron are reported to have been made to Germany, France, Belgium, Scandinavia, and other countries abroad. No. 1 is as scarce as ever and commands 97*s.* 6*d.*; No. 3 g.m.b. is 92*s.* 6*d.*; No. 4 foundry, 92*s.*; and No. 4 forge, 91*s.* 6*d.*—all f.o.t. or f.o.b.

Hematite.—Slightly better accounts are given of East Coast hematite iron. Makers have sold fair quantities lately and are inclined to take a firmer stand. Home and export demand is expected to improve. Values, however, whilst showing upward tendency, are not actually advanced. Nos. 1, 2, and 3 are still on sale at 99*s.*, and No. 1 is quoted 100*s.*

Foreign Ore.—There is little or nothing passing in foreign ore; consumers, having good supplies and being off the market, quotations are still based on best rubio at 24*s.* c.i.f. Tees, but they are nominal.

Blast-furnace Coke.—Durham blast-furnace coke is distinctly easier, though sellers are very reluctant to acknowledge any fall in quotations. Customers claim they can satisfy their needs at round about 30*s.* for good average qualities delivered to their works.

Manufactured Iron and Steel.—New features of moment in finished iron and steel are few. Generally orders are still scarce, but for some descriptions of material rather more inquiry is circulating. Among the principal quotations are:—Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.*; fish plates, 13*l.*; and galvanised corrugated sheets 24-in. gauge, in bundles), 17*l.* 10*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—As usual some interesting facts concerning the Welsh coal trade are revealed in the Board of Trade returns, just issued, showing the output, cost of production, proceeds and profits of the industry in the three months ending December 31 last. It is shown that the output in South Wales amounted to 12,503,280 tons of which 11,438,239 tons was commercially disposed of, the remainder being used for mine consumption and supplying the workmen with coal for domestic purposes. The cost of producing the coal amounted to 11,779,660*l.* or 20*s.* 7·16*d.* per ton, from which must be deducted 106,626*l.* or 2·24*d.* per ton, the proceeds from the coal supplied to the miners, leaving the net costs at 11,673,034*l.* or 20*s.* 4·92*d.* per ton. The proceeds derived from the coal commercially disposed of amounted to 12,334,434*l.* or 21*s.* 6·80*d.* per ton, leaving a profit of 661,400*l.* or 1*s.* 1·88*d.* per ton. The wages cost of production totalled 7,821,549*l.* or 13*s.* 8·11*d.* per ton, the cost of stores and timber 1,666,139*l.* or 2*s.* 10·96*d.* per ton, and other costs, including management, salaries, insurances, repairs, office and general expenses and depreciation to 1,833,526*l.* or 3*s.* 2·47*d.* per ton. The number of workpeople employed during the quarter totalled 226,830 and 15,441,512 man-shifts were worked, while 1,293,783 man-shifts were lost which could have been worked. The output of coal per man-shift worked was 17·20 cwt. and the earnings per man-shift worked was 10*s.* 1·57*d.*

Imports of Mining Timber.—Practically the whole of the timber used in the South Wales collieries is imported from abroad and particularly from France. In the quarter ended March 439,542 loads of pitwood and pitfuls were landed in South Wales. The f.o.b. value of this timber amounted to 550,426*l.* Imports in March amounted to 171,973 loads valued at 210,763*l.*, which represented an increase of 79,612 loads and 94,025*l.* on that imported in February. The bulk of the imports were received at Cardiff where 108,669 loads were discharged compared with 51,515 loads in February, while Newport landed 32,768 loads against 23,719 loads, Swansea 9,079 loads against 9,282 loads, Port Talbot 20,947 loads against 7,695 loads and Llanelly 510 loads against 150 loads. Supplies received from France amounted to 156,162 loads compared with 82,587 loads in February, while Spain contributed 3,776 loads against 1,702 loads, Portugal 9,199 loads against 7,846 loads, Irish Free State 786 loads against 226 loads and Sweden 2,050 loads against nil.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been little change in the conditions ruling in the steel trade of Scotland during the past week, but the demand for shipbuilding material is gradually getting less. In the latter industry, however, the outlook is a trifle better, and it is not anticipated that the present lock-out will be of long duration. Another factor of no little importance to the steel trade is the possibility of a disagreement in the coal trade over the wages question. When everything is taken into account the prospects of an improvement in the demand for steel are not very good. Buyers are not covering any more than their current requirements as they cannot see any distance ahead. Inquiries are fair, but not very many of them have recently been translated into actual business. The makers of black sheets are doing fairly well, but while fresh bookings are few the amount of work on hand is still very good and sufficient to keep makers well employed for some time yet. No change has been made in quotations lately and these are as follows:—Boiler plates, 13*l.* 10*s.* per ton, ship plates, 10*l.* 5*s.* per ton, sections 10*l.* per ton, and sheets 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—There has been practically no change in the malleable-iron trade of the West of Scotland over the week and were it not for the business booked some time ago most of the establishments would be very badly off indeed. Buyers are conspicuous by their absence, and it is hoped that a few more orders may be forthcoming soon or else the outlook will be very black and the ranks of the unemployed will be considerably increased. Prices are unaltered with "Crown" bars called 12*l.* 10*s.* per ton, delivered at Glasgow stations.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade there is a trifle more business passing, and while some of it is on home account the bulk is for overseas. Inquiries have also improved to some extent but the old difficulty of price remains as buyers and sellers cannot see eye to eye, and when business results very keen quotations have to be accepted by producers. All transactions are a matter of arrangement but the following may be taken as the current prices:—Hematite, 5*l.* 2*s.* 6*d.* per ton delivered at the steelworks; foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, both on trucks at maker's yards.

General Trade.—Despite the many labour disturbances at the present time and the prospect of others coming on in the near future general trade throughout the country is really not bad. Some industries are better placed than others, but over all there is a wonderful amount of business going through. Shipbuilders have booked quite a number of orders within recent months and many of these can now be commenced since the recent dispute is settled. Among the latest of these reported are two vessels, each of 2,500 tons for the fruit-carrying trade. One is to be built at Aberdeen by Messrs. John Lewis & Sons (Limited), and the other at Linthouse by Messrs. Alex. Stephen & Sons (Limited). In each case the builders will supply the engines. The demand for textile machinery is not very heavy at the moment, but makers of railway material have again received some more orders and have now a large tonnage on hand. While conditions generally are somewhat unsettled it is realised that if a period of calm could be assured in the labour market a steady flow of business would be forthcoming.

GERMAN COAL PRODUCTION.—Particulars are given by the Board of Trade from the latest issue of *Wirtschaft und Statistik*, of the production of coal, coke, and lignite in Germany, during 1923, and previous years. The coal produced last year amounted to 62 million metric tons, as compared with 119 million metric tons in 1922, and 140,753 millions in 1913, from the corresponding area of Germany, excluding the Saar district.

THORNYCROFT COMMERCIAL VEHICLES.—The 18th Annual Parade of the Commercial Motor Users' Association was held in Lincoln's Inn Fields on Saturday, the 12th inst., when some 130 petrol and steam vehicles were entered, in teams of three, owned by many of the largest and most experienced users of motor transport. After every vehicle had been carefully scrutinised by an expert tribunal of judges the "Commercial Motor" Cup and First Prizes were awarded to the team of three Thornycroft lorries entered by Messrs. Thomas Wethered & Sons, Limited, Brewers, of Marlow. Messrs. Wethered were also winners of the Cup at the 1922 and 1923 Parades, and this third consecutive win entitles them to absolute possession of this trophy which has been competed for annually since 1910. The drivers of the winning vehicles were awarded the Shrapnell-Smith Challenge Cup in addition to their individual prizes and souvenir medals.

THE LATE MR. HENRY SMITH.—We regret to have to record the death, which occurred on the 17th inst., at 37, Holland-street, Kensington, W. 8, of Mr. Henry Smith, who was for many years a director of James Simpson and Co., Limited, and Worthington-Simpson, Limited. Mr. Smith was born in February, 1849, and served an apprenticeship of seven years, from 1865 to 1872, at the works of Messrs. Pearce Bros., Lily Bank Foundry, Dundee, passing through the various shops and the drawing office. In March, 1872, he entered Messrs. Simpson and Co.'s engine works, Grosvenor-Road, Pimlico, as draughtsman, where, for the first two years, he was engaged on marine work and then on several pumping plants until March, 1877, when he was appointed chief draughtsman. In the year 1885, Mr. Smith was appointed manager of the drawing and designing department of the company, and in 1886 went to the United States to examine and test at the Worthington Works the compensated Worthington engine which had just been patented by its inventor. In 1890 Mr. Smith was made a director of Messrs. Simpson and Co., and held a seat on the Board of Messrs. Worthington-Simpson, Limited, from the time of the amalgamation until his death. He was a member of the Institution of Civil Engineers, of the Institution of Mechanical Engineers, and of other technical societies.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night, at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette, "Aluminium Electrical Conductors for Overhead Power Transmission," by H. G. Williams.

THE INSTITUTION OF ENGINEERING INSPECTION.—To-night at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2, "Radiology in Inspection," by Mr. V. E. Pullen, B.A., B.Sc.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, April 26, at 2 p.m., in the Lecture Theatre of the Institute, Newcastle-on-Tyne. Papers for further discussion: "The X-Ray Analysis of Coal, with Scientific and Technical Applications," by Mr. C. Norman Kemp, B.Sc.; "Experiments on the Distribution of Air in Centrifugal Fans and on Re-entry Phenomena," by Professor Henry Briggs, D.Sc., Ph.D., and James N. Williamson, B.Sc. Papers to be read: "Safety Lamps giving warning of Gas," by Dr. W. M. Thornton, O.B.E.; "The Scientific Treatment of Boiler Water, introducing the Colloidal Aspect," by Mr. H. W. Bannister.

THE FARADAY SOCIETY.—Monday, April 28, at 3 p.m., at the Institution of Mechanical Engineers, Storey's-gate, S.W.1. General discussion with the Institute of Metals, the British Non-Ferrous Metals Research Association and the Institute of British Foundrymen, on "Fluxes and Slags in Metal Melting and Working." General introduction by Professor C. H. Desch, F.R.S. Part I, "Oxidising Fluxes in the Melting of Non-Ferrous Metals," by A. Portevin. "The Use of Fluxes in Brass Melting," by A. L. Haughton and R. Genders. "Note on Slags from Lead, Copper and other Blast Furnaces," by G. Riff. "Slags in Relation to Copper and Brass," by Dr. A. Scott. "Slags Produced in Melting Silver Alloys," by J. Phelps. "Sulphurizing and Desulphurizing of Metals by Basic Slags and Fluxes," by B. Bogitch. Part II, at 5 p.m., "Slag Inclusions in Relation to Fatigue," by Prof. B. P. Haigh. "Fluxing Problems in Welding of Mild Steel with the Metallic Arc," by H. Ogden. "Fluxes and Slags in Oxy-Acetylene Welding," by C. Coulson-Smith. "Fluxes and Slags in Welding," by W. Spraragen. "The Use of Fluxes in the Melting of Aluminium and its Alloys," by Dr. W. Rosenhain and L. Archbutt. "Note on Non-Metallic Inclusions in Metals with Special Reference to Aluminium," by A. G. Lobley. "Fluxes Used in the Tin-Plate Industry," by Dr. G. T. Bailey. "Fluxes in Soft Soldering," by T. B. Crow.

THE ILLUMINATING ENGINEERING SOCIETY.—Monday, April 28, at 8 p.m., at the Royal Society of Arts, John Street, Adelphi, W.C. 2. Discussion on "Some Problems in the Lighting of Textile Mills," by Mr. E. L. Oughton (Gas Lighting) and Mr. P. J. Waldram (Daylight Illumination).

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 29, at 6 p.m., at Great George-street, S.W.1. Ordinary Meeting. Papers to be submitted for further discussion: "The Barton Power Station of the Manchester Corporation and the Transmission System in Connection therewith," by Henry Newmarch Alliott, M.Inst.C.E., and Standen Leonard Pearce, C.B.E., M.Inst.C.E.; "Dalmarnock Electricity Works," by William Burnside, Assoc.M.Inst.C.E. Wednesday, April 30, at 6 p.m. Students' meeting. Annual General Meeting of the Association of London students.

THE ROYAL SOCIETY OF ARTS,—Wednesday, April 30, at 8 p.m., at John-street, Adelphi, W.C. 2. Ordinary Meeting. "The London Dock District and its Roads," by Brigadier-General Sir Henry Maybury, K.C.M.G., C.B. Friday, May 2, at 4.30 p.m. Indian Section.—"Chemical Research in India," by Jocelyn F. Thorpe, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, April 30, at 8 p.m., at the Society's Rooms, 9, The Temple, Dale-street, Liverpool, Annual General Meeting.

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, April 30, at 6 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Lecture, "Faithful Reproduction by Broadcast," by Captain P. P. Eckersley.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 2, at 9 p.m. The Evening Discourse will be delivered by Sir Alexander Kennedy on "Petra."

THE SOCIETY OF CHEMICAL INDUSTRY: CHEMICAL ENGINEERING GROUP.—Friday, May 2, at the Engineers' Club, Coventry-street, W.1, Annual General Meeting.

THE INSTITUTE OF METALS.—SWANSEA LOCAL SECTION. Friday, May 2, at 7.15 p.m., in the Metallurgical Department, University College, Singleton Park. Annual General Meeting,

MACHINERY IMPORTATION OF BRITISH MALAYA.—Comparative returns of machinery imports by British Malaya during the past two years indicate a slightly increased value of electrical machinery and engines, boilers and parts imported in 1923, but a serious drop in the value of other machinery. The present tendency is to develop the use of electrical power on the tin mines and in connection with this, Sir W. G. Armstrong, Whitworth and Co., Limited, obtained an agreement with the Government in 1923, granting them the exclusive right of survey of hydro-electric possibilities in Perak for a term of one year. There is a demand for improved machinery in the rubber and cocoanut industries.

INDUSTRIAL NOTES.

THE Ministry of Labour state that employment showed a further improvement in March. Among workpeople insured under the Unemployment Insurance Acts in Great Britain and Northern Ireland the percentage unemployed on March 24 was 9·9, compared with 10·7 on February 25, and with 11·5 in March, 1923. Among members of Trade Unions from which returns were received the percentage unemployed was 7·8 at the end of March, compared with 8·1 at the end of February. The total number of workpeople registered on March 31 at Employment Exchanges in Great Britain and Northern Ireland, as applicants for employment, was approximately 1,057,000, of whom 791,000 were men and 204,000 were women, the remainder being boys and girls; on February 25 the total was 1,156,000, of whom 858,000 were men and 227,000 were women. Employment was good in the coal mining industry, in the tinplate, steel sheet, carpet, jute and coach-building trades, and with skilled operatives (except painters) in the building trades; it was fairly good with millsawyers, brickmakers, and in certain sections of the metal trades.

The upward tendency in wages continued during March. In the industries for which statistics are available the changes reported resulted in an aggregate increase of nearly 30,000*l.* in the weekly full-time wages of nearly 600,000 workpeople and in a reduction of about 7,500*l.* in the weekly wages of over 180,000 workpeople. Among the workpeople whose wages were increased were coal miners in the Yorkshire and East Midland area and in Scotland, whose wages were increased by about 1¾ and ½ per cent., respectively, on current rates. Other important groups of workers who received increases included iron ore miners in Cumberland, iron puddlers and millmen in the North of England and West of Scotland. The principal groups of workpeople whose wages were reduced were coal miners in Durham and in the Forest of Dean, who sustained reductions of about 1¾ per cent. and 3½ per cent., respectively, on current rates. During the first three months of 1924 the changes in rates of wages reported to the Labour Department have resulted in net increases of over 206,000*l.* in the weekly full-time wages of over 1,700,000 workpeople and in net reductions of nearly 36,000*l.* in the wages of 590,000 workpeople. In the corresponding period of 1923 there were net increases of about 19,500*l.* in the weekly full-time wages of nearly 190,000 workpeople and net reductions of over 160,000*l.* in the weekly wages of nearly 1,600,000 workpeople.

On April 1 the average level of retail prices of the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was approximately 73 per cent. above that of July, 1914, as compared with 78 per cent. a month ago and 74 per cent. a year ago. For food alone the corresponding percentage for April 1 was 67, as compared with 76 a month ago and 68 a year ago.

The number of trade disputes involving stoppages of work, reported to the Labour Department as beginning in March, was 59. In addition, 21 disputes, which began before March, were still in progress at the commencement of the month. The total number of workpeople involved in all disputes in March was approximately 76,000, as compared with 144,000 in the previous month, while the estimated aggregate duration of all disputes during March was about 730,000 working days, as compared with 700,000 days in February. The principal stoppage was that involving nearly 40,000 tramway and omnibus workers in London. During the first three months of 1924 the stoppages of work owing to trade disputes reported to the Department have involved approximately 288,000 workpeople, as compared with 125,000 workpeople involved in disputes in the first three months of last year. The aggregate duration of the stoppages in the period January to March, 1924, has been nearly 2,100,000 working days, as compared with over 1,200,000 days in the corresponding period of 1923.

The Court of Inquiry appointed by the Minister of Labour under the Industrial Courts Act, 1919, to investigate and report upon the dispute in the coal industry, is constituted as follows: The Right Hon. Lord Buckmaster, chairman; Mr. Roscoe Brunner and Mr. A. G. Cameron. The secretaries are Mr. C. S. Hurst and Mr. H. C. Emmerson. The terms of reference are: "To inquire and report upon the question of wages in the coal mining industry and the matters in issue between the Mining Association of Great Britain and the Miners' Federation of Great Britain relating thereto." A meeting was held in London just before the Easter holidays between representatives of the coalowners and of the Miners' Federation, when it was decided to continue the working of the collieries under day-to-day contracts until the inquiry had been held and the report presented; it was also agreed by the coalowners to put into operation, as from May 1, the new agreement as to the minimum percentage, the ratio of profits to wages and the results of the ascertainments for January and February. The present rates of wages continue until the 30th inst. Speaking in Parliament before the Easter recess, the Minister of Labour thought there was every prospect not only of avoiding a stoppage, but of coming to an understanding which, he hoped, would bring peace to the mining industry for a very considerable time to come.

The unofficial strike of the shipyard workers which had lasted about nine weeks came to an end last Saturday, the men deciding to resume work. As a consequence, the lock-out at other shipyards throughout the country has been cancelled. The Southampton men went back to work last Wednesday, and their claims are now being considered by the employers. The men have secured nothing by striking, and their action means a considerable loss to themselves and to the country as a whole. Moreover, there is for the time being not sufficient employment available at Southampton for the whole of the men who went out on strike.

The building trades' operatives who, as stated in our last issue, put forward a claim for an increase in wages of 2*d.* per hour, a claim which was not agreed to by the employers, are going to take a ballot on the question. The men will be asked to state (1) Whether they are in favour of accepting the employers' offer—namely, ½*d.* per hour increase, as from May 1, in respect of those areas which have not been up-graded recently, and ¼*d.* per hour as from August 1 in areas which have already been up-graded. (2) If not in favour of accepting the employers' offer, whether the men are agreeable to further negotiations either through a possible conference being promoted to this end by the Trades Union Congress or the Ministry of Labour, with a view to improving the present offer of the employers. (3) Failing an improved offer, whether the men are in favour of strike action.

The votes are returnable on the 28th inst. The operatives affected number 700,000.

NOTES ON NEW BOOKS.

THE term "applied mechanics" seems to be used in different senses by different writers. Rankine's famous treatise on the subject deals with stresses on structures, the kinematics of machinery, the flow of fluids, dynamical principles, and the theory of machines. A much more limited signification is evidently attached to the term by Professor T. Alexander, and Professor A. W. Thomson, who have just had published a third edition of their "*Elementary Applied Mechanics.*" This treatise is concerned solely with the determination of stresses in structures, and is intended rather for the civil engineer and bridge builder than for mechanical engineers in general. Within the limits there set the work is very comprehensive and gives not only a large number of examples worked out in detail, but each chapter is followed by a well-selected series of questions by which the student can test his comprehension of the preceding text. Among the new matter is a chapter dealing with the maximum stresses produced by a locomotive moving over a short girder. In addition to structural steel work, there are also chapters on masonry retaining walls and on masonry arches. The book is strictly limited to the immediate "practical" needs of the civil engineer. There is no discussion of the general equations of the mathematical theory of elasticity, nor much reference to the actual behaviour of structures in service. Numerous illustrations are included in the text. The volume is published by Messrs. Macmillan and Co., Limited, at 15*s.* net.

"*Modern Wood Working Machinery,*" by Stafford Ransome, M.Inst.C.E. [London: William Rider and Son, Limited. Price 12*s.* 6*d.* net.] is a new edition of a well-known work, and it is well worthy of study by potential purchasers of the latest types of wood-working machinery. It is also a work of great interest to the looker-on, since it contains chapters written in very simple language dealing with the general theory and practice of handling timber, and gives a very practical insight into the design, construction, uses and capacities of wood-converting machines by an author with very wide experience. The volume contains a large number of illustrations, including one of a steam tree feller, and we are of opinion that it would have added interest to the work if the author had included a chapter on the gear designed for felling, cross-cutting, and bringing the logs from the forest to the sawmill. The appliances used for such purposes in the American and Canadian forests are of great interest, particularly the rams which are designed to manœuvre logs weighing several tons. The author deals in an unbiassed manner with many alternative methods and machines for treating timber in its finished state, and the chapter on scraping and sandpapering machinery deserves special notice: the product of such machinery is of so high a standard that it is permissible to transfer the wood direct from it to the polishing shop.

French authors seem to have a special gift for descriptive work, and this tradition is sustained in the volume dealing with the "*Production et Condensation de la Vapeur,*" by M. E. Sauvage, which has been published by Messrs. J.-B. Baillière et Fils, Paris, at 35 francs. The aim of the author is indicated at the very outset by the remark that for practical purposes it suffices to take the specific heat of superheated steam as 0·5, thus indicating that the highly important theoretical and experimental investigations made during the last 25 years on the properties of steam are to be of set purpose ignored as irrelevant to the main intention of the book. Accepting this scheme, it may be said at once that M. Sauvage has given a very full and capitally illustrated description of the appliances used in generating and condensing steam. He includes the boiler-house equipment of conveyors, elevators and cranes, and has quite a long section on different forms of grate and various automatic stokers. Methods of utilising oil fuel are also illustrated. He also deals with the relationship between draft and rates of combustion. The engravings given include sections and plans of actual boiler lay-outs. Other illustrations indicate the essential characteristics of different types of boiler. Adequate space is devoted to fittings and piping. The section dealing with condensers is written on similar lines, with a minimum of theoretical discussion, but with very numerous illustrations drawn from current practice.

The most important section in "*Die Physikalischen und Chemischen Grundlagen des Eisenhüttenwesens*" ("Physical and Chemical Principles of the Metallurgy of Iron"; Leipzig: Otto Sparner; 2nd edition; price 27 gold marks), by Professor Walther Mathesius, of the Berlin Technical High School, is the theoretical chapter on the blast-furnace process. This theory was, in the first edition of the volume of 1915, based upon experience and upon detailed replies to enquiries addressed to a large number of German ironworks smelting different kinds of ores. The conclusions drawn, summarised in many tables and sheets of graphs, as to chemical reactions, thermal balances, coke consumption and furnace dimensions, are now confirmed by recalculation of the data furnished by twenty works, comprising one American firm. Professor Mathesius recommends blast furnaces of large diameters and relatively small height, the use of suitably disintegrated materials and of a readily combustible coke, and the combination of scrap melting with ore smelting. He does not believe that the efficiency of the blast furnace can be raised by the use of oxygenated air; that would be possible, in his opinion, however, in the case of ferro-alloys. The theoretical section takes up nearly a hundred pages out of a total of 483 pages. The other main sections deal with the production of mild steel and with iron and steel foundry processes.

SOUTH WALES PORTS.—A very complete and admirably got-up book, produced and published by Mr. H. N. Appleby, by arrangement with the Great Western Railway Company, gives extensive information on the ports of South Wales, their accommodation, the facilities they offer, their trade, various charges, &c. It is illustrated by a large number of views, plans and maps.

SOUTH AFRICA—IRON, STEEL AND BRASS TUBES.—H.M. Trade Commissioner at Cape Town reports that the South African Railways and Harbours are inviting tenders for the supply of charcoal iron boiler tubes, brass boiler tubes, steel boiler tubes and steel superheater flue tubes. Tenders must be received not later than noon on June 16. United Kingdom firms desiring further particulars should apply to the Department of Overseas Trade, 35, Old Queen-street, S.W.1, quoting reference 13539/E.D./E.C.

SUB-INSPECTORS OF MINES AND QUARRIES.—Mr. E. Shinwell, M.P., Secretary for Mines announces that he is prepared to receive applications for nominations to attend competitive examinations that will be held shortly to fill vacancies on the staff of the Mines Inspectorate. The vacancies and divisions are as follow:—2, Midland and Southern; 3, York and North Midland; 3, South Wales; and 1 each, Scotland, Northern and Lancashire and North Wales. There is a vacancy for the position of Sub-Inspector of Quarries in the Midland and Southern Division. Forms of application and full particulars of these posts can be obtained from the Establishment Branch, Mines Department, Dean Stanley Street, Millbank, Westminster, London, S.W.1. Applications for nomination will not be considered unless the prescribed forms, duly completed, are received in the Mines Department not later than Wednesday, May 7.

THE BRITISH EMPIRE EXHIBITION.

It will be for those of a later generation to estimate the place which the British Empire Exhibition of 1924 is to take in the history of the development of our Empire, but even we who live with the event cannot but feel that the formal opening this week may well mark a definite stage in the story of British achievement. The opening marks the culmination of an effort which with its enterprise and single-hearted endeavour may well stand as an epitome of the building of the Empire for whose commonweal it has been made. The outline of the story of this endeavour we tell below, and it can be but the hope and belief of all who by right of birth have some part in the Exhibition, that the effort and its fruit may be rewarded by a success consonant with their worth. Certain it is that everything foresight, ingenuity and hard work could do have been expended without stint on the very remarkable display which is to be seen at Wembley. Final success now rests with the public, and that part of the public which we more particularly address will find enough of engineering, scientific and industrial interest to justify many more than one visit we assert with no hesitation.

The present exhibition, though it has, of course, all been organised since the war, is the result of movements dating back much earlier. As long ago as 1910 the High Commissioners of South Africa, Canada, and Australia had promised their support to a British Imperial Exhibition that was then projected, and by February, 1911, the General Council of an Imperial Exhibition had raised a guarantee fund of 2,000*l.* for preliminary expenses, which they resolved to increase by 15,000*l.* or more. The adhesion of important authorities and individuals continued to increase, until by the middle of 1912 the committee had grown to 167 members. By that time negotiations were satisfactorily in progress to take Earl's Court for the exhibition, and it was resolved to raise a guarantee fund of 30,000*l.*, which the late Lord Strathcona supported with his customary munificence in Imperial matters.

Meanwhile the financial position of the Crystal Palace was giving rise to grave anxiety; and towards the end of 1913, when its existence had been saved by the energetic and public-spirited interposition of Lord Plymouth, it was resolved that the exhibition should be held there. The organisation had begun in 1910 with a meeting at the Royal Colonial Institute under the chairmanship of Lord Strathcona, at which he was elected President and a committee appointed. By the end of 1913 the Grand Council numbered over 1,000 men of eminence in politics, education and business, with Sir Arthur Birch, previously of the Bank of England, as Chairman of the Finance Committee, and Mr. C. J. Stewart, the Public Trustee, as Honorary Treasurer. The year 1915, which had been selected as the date of the exhibition, was notable as the centenary of the beginning of uninterrupted peace with France, as well as the 700th anniversary of the grant of Magna Charta, and it was convenient because the Imperial Conference would then be sitting. The occasion thus seemed, as Lord Strathcona pointed out, to be a unique opportunity for reviewing our Imperial blessings and our Imperial responsibilities, and, as urged by Mr. William Crooks, for bringing home to the people a sense of the importance and the extent of the British Empire. Adhesions to the Grand Council continued to come in both from the United Kingdom and the Dominions. The lease of the Crystal Palace was signed in April, 1914, and arrangements were completed with the London County Council for the erection of organisation buildings on an Aldwych site.

The outbreak of war arrested and quickly put an end to these preparations, but their history, of which the leading incidents are described above up to within a year of the date when the exhibition should have opened, shows fairly the extent to which the proposal of an Imperial Exhibition had found support. It had clearly been approved by individuals among the most eminent in the Mother Country and in the largest Dominions, it was on the way to provide a successor to previous exhibitions of the type of that devoted to the Colonies and India in 1886, and in both its scale and its prospects it was of much the same order as that and similar exhibitions. Indeed, whatever may have been the wish of the distinguished persons associated with the scheme, the time available for obtaining the promise of exhibits, for preparing them, and for arranging for their accommodation, would have necessarily put some such limit on the scope of the intended 1915 exhibition, even if its financial backing had been much larger than it was; and there seems no reason to doubt that such a limitation was in accordance with the general feeling at the time at which the arrangements were made.

Scarcely, however, had the Armistice been concluded than proposals for a British Empire Exhibition were renewed and taken actively in hand. Early in 1919 the Government was approached by two separate and influential groups, each contemplating the organisation of an Imperial Exhibition in London. At the suggestion, as it is understood, of the Government these groups amalgamated, forming, under the chairmanship of Lord Morris, a provisional committee, which incorporated a company limited by guarantee. At a Conference of Ministers of the United Kingdom and High Commissioners and Agents-General of all the great Dominions held in May, 1919, at the British Empire Club under the auspices of the British Empire League, it was resolved unanimously that the exhibition was desirable. The grounds of this resolution were expressed to be not merely, as with the pre-war project, to stimulate Imperial trade by helping manufacturers to secure a larger share in the growing markets of the Dominions and to help in developing resources within the Empire that were only partly developed or not developed at all, but also to provide a memorial of the part the Empire had played in the war in demonstrating its unity and its resources. With the encouragement of this resolution and, as we understand, of H.M. Government, considerable enquiry was made during the next twelve months into the actual prospects of the proposal, and it became evident that the desire for the exhibition was so widespread and the scope that would be necessary to do justice to the purposes of those who approved of it was so great as to require resources and preparations on a far greater scale than had been contemplated. Ultimately, at the suggestion of H.R.H. the Prince of Wales, the scheme, of which H.M. the King had consented to be Patron and H.R.H. the President of the General Committee, was officially inaugurated and approved at a meeting at the Mansion House in June, 1920. A guarantee fund had been started among leading banking and business companies, which by then had reached some 108,000*l.*; and it was arranged that, while the direction of the exhibition was to be entrusted solely to the executive committee, its final constitution was to be subject to the approval of the Board of Trade, which was also to approve all regulations affecting the participation of the Dominions, India, the Colonies and Protectorates, and the entry of British exhibitors. As objects hardly less important than those for which the exhibition had been promoted up to then it was decided further that it should include such exhibits as would tend to arouse interest in scientific research, preventive medicine (including the study of diseases of animals and plants), public health, and social welfare, and to cement still more closely the relations between the constituent parts of the British Empire.

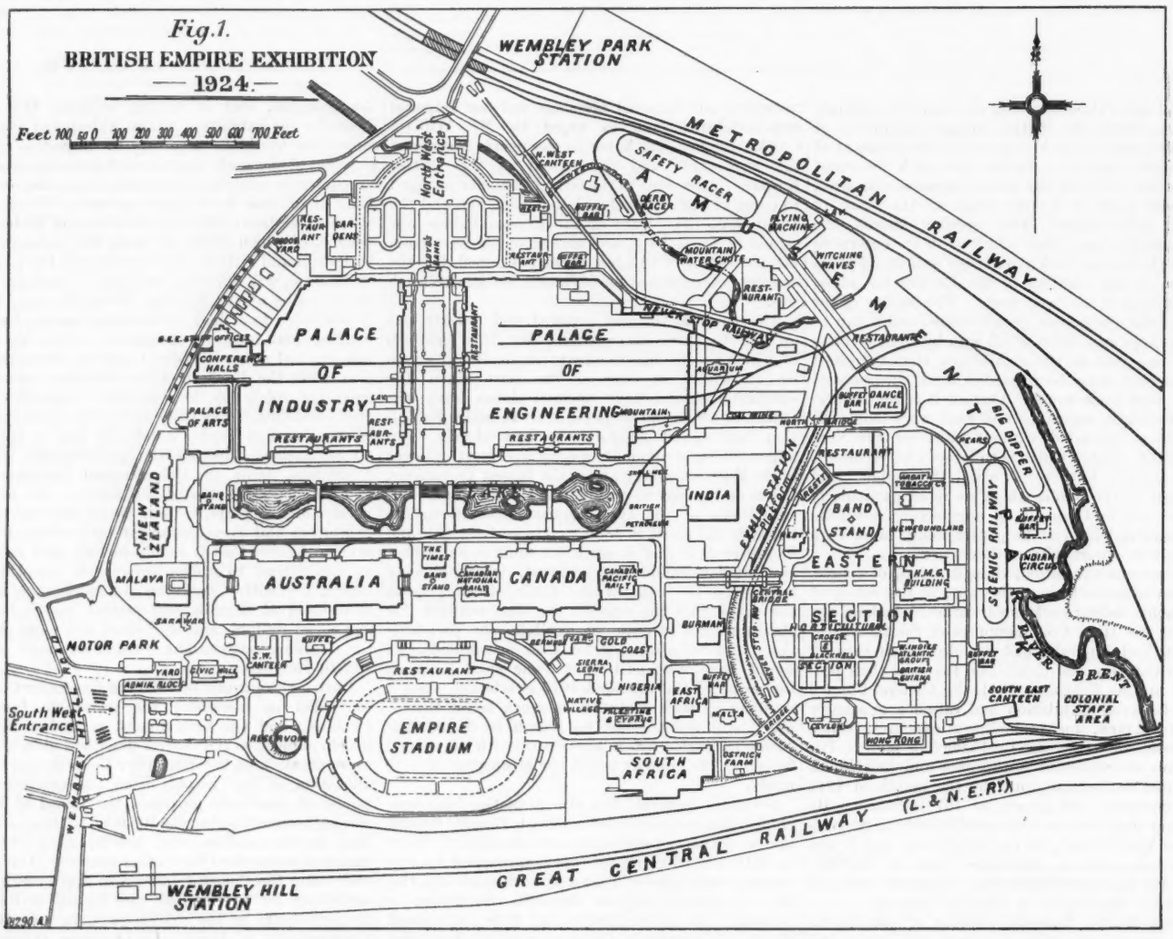
During the autumn of 1920 the Executive Council succeeded in increasing the guarantee fund to 150,000*l.*, and the Government carried a Bill by which, subject to the control described above, to its representation on the Executive Council, and to the allocation of any surplus from the exhibition to public or charitable purposes, the Board of Trade was authorised to subscribe 100,000*l.* to the guarantee fund on the condition that not less than 500,000*l.* had been subscribed from other sources. The India Office and the Colonial Office also appointed representatives on the Council, and formal invitations to participate in the exhibition were sent to the Governments of India, the Overseas Dominions, and the Colonies. During the winter of 1921 possible sites for the exhibition were examined, with the result that Wembley Park was selected and negotiations opened for purchasing the site. In July, 1921, a meeting of the Council was held, attended by the Prime Ministers of Australia and New Zealand, the High Commissioner for India, and representatives of the Prime Ministers of South Africa and Canada, at which all of them pledged their respective countries to do their utmost to make the exhibition a success.

The meeting was the occasion of several notable declarations, which served further to define the function of the exhibition. Sir Robert Horne, the then Chancellor of the Exchequer, pointed out that, while practically every product that man can want existed or could be produced within the Empire, the truth of this comprehensive proposition was not realised generally, and no sufficient mechanism existed either for the exchange of such products to the mutual benefit of all the communities concerned,

or for showing the inhabitants of each country of the Empire what the others were doing and producing. Mr. Hughes, then Prime Minister of Australia emphasised in particular the general lack of acquaintance of citizens of the United Kingdom with the other part of the Empire, asserting that if he only knew of Australia what could be read in the London press, it would be the last place on God's earth to which he would wish to go, and that closer and more accurate knowledge of each other were essential to the purposes that the exhibition was meant to promote. Mr. Massey, the Prime Minister of New Zealand, urged that the Crown Colonies and Protectorates, some of which would some day become Dominions, should also participate; and Colonel Mentz reminded the Council that, if South Africa had to sell outside the Empire, economic forces would compel it also to buy there. Finally, Sir William Meyer, the High Commissioner for India, addressed a powerful appeal to the Lord Mayors and Mayors of the principal cities and boroughs of the United Kingdom, in which he invited them to form local committees for raising the guarantee fund, and on the eve of his departure for India presided at a meeting held at the Mansion House, at which a general appeal to the country was launched. Following these steps on the Prince's part, and the activity to which they gave rise in all parts of the country, the agreed minimum was subscribed before Christmas; and it may be questioned whether so rapid and successful a result could have been obtained but for the Prince's vigorous and opportune action. While, however, the appeal was maturing, the scheme was exposed to a danger by which, though it is not generally known even at the present time, the prospects of its success were seriously threatened. The Wembley Park site was the only suitable one that had been found available at a cost the mention of the generous and courageous act by which the site was preserved.

The work of preparing the site was accordingly begun early in January, 1922, and later in the month a mission was sent off to some of the principal Dominions for the purpose of discussing the plans of the pavilions, the nature and methods of displaying the exhibits, and the manner in which the several incidental objects of the exhibition could best be promoted. The mission consisted of the Assistant General Manager of the Exhibition, Major E. A. Belcher, C.B.E., with the Agricultural and Financial Advisers and a Secretary. In South Africa it settled the general lines of participation, which were subsequently enlarged. Three months were spent in Australia in consultation with the individual States, at the end of which time a conference of Commonwealth and State authorities was held, at which it was resolved to spend 250,000*l.* on the

Fig. 1.



suggested that the date fixed for the exhibition, which up to then had been 1923, should be altered to 1924, both to enable further recovery from the effects of the war to be made before the opening, and to allow exhibitors to take their exhibits on to the Inter-Allies Exhibition that was to be held in Paris in 1925.

The position, therefore, up to this date was that, though the desire for the exhibition had been shown conclusively by reiterated evidence, and its intended scope had been continually widened, the resources at its back, though steadily increasing, were much smaller than were necessary to enable the whole scheme to be carried out. What followed was a remarkable illustration of the influence that can be exercised by individual action in crystallising into a tangible form a feeling in the public mind that till then had lain in solution. The best estimate of the minimum guarantee that would enable the exhibition to be carried through on the scale then contemplated was 1,000,000*l.* The Prince of Wales that could be entertained, and the option of purchase was to expire at the beginning of August and was not open to be renewed. The Council had no funds for paying the deposit by which the property could be secured, and could find no means for raising them until the guarantee fund had become sufficient to assure the scheme being carried through. At literally the last moment the situation was explained to an East Anglian farmer of known enterprise and public spirit, and on the spot he paid the 6,000*l.* deposit necessary to secure the property, relying—as the event proved, with sound judgment—on the effect of the Prince's appeal and the Mansion House meeting to secure the balance before completion was required. By his own wish his part in this transaction has never been published, and doubtless a reputation for producing large sums on demand without security or profit might lead to an inconvenient popularity. The incident, however, was of particular consequence to the exhibition, and the account of its history would be incomplete without exhibition. An Exhibition Committee was set up with its headquarters at Melbourne, composed of political and business representatives of each State under the presidency of Mr. Bruce, the Prime Minister, and State Committees were formed with the necessary panels for agricultural, pastoral, viticultural, mining, industrial, and other activities. There seems to be no doubt that this resolution did much to establish the scale of participation of the other constituent Dominions. The Commission went next to New Zealand, where an allocation of 60,000*l.* was voted, which has since been increased. The organisation here was directed by a Council composed essentially of business men, and in order to assure the most effective result the State took up the entire space allotted to the Commonwealth, making no charge to those whose products were exhibited and bearing all expenses. From there the Commission proceeded to Canada, where 1,000,000 dols. were voted; and, finally, to Newfoundland, where the Government decided definitely

THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page 527.*)

Fig. 2. The India Pavilion from the Lake.

Fig. 3. The Burmah Pavilion.

(*To face page 524.*)

THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 527.)

Fig. 4. The Canada Pavilion.

Fig. 5. The Australia Pavilion.

(*To face page* 525.)

THE BRITISH EMPIRE EXHIBITION; MACHINE TOOLS.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 553.)

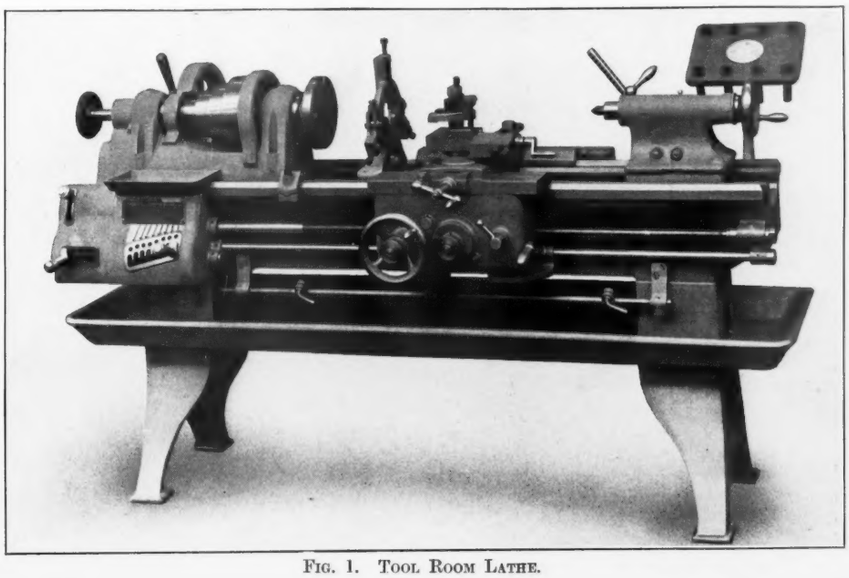


Fig. 1. Tool Room Lathe.

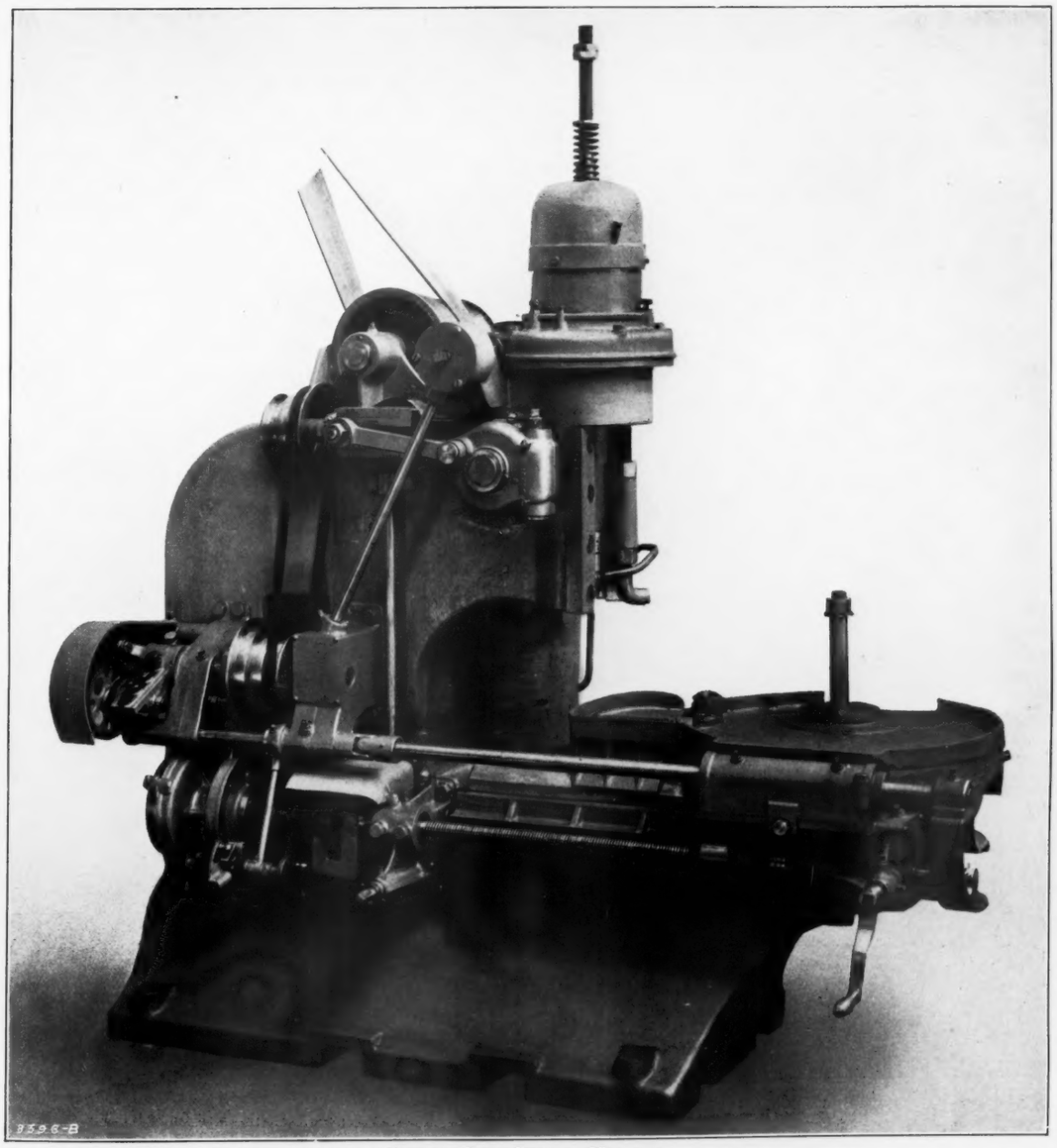


Fig. 2. Gear Shaping Machine.

(*To face page* 552.)

THE BRITISH EMPIRE EXHIBITION; WOODWORKING MACHINERY.

CONSTRUCTED BY THE DOMINION MACHINERY COMPANY, LIMITED, HALIFAX.

(*For Description, see Page 553.*)

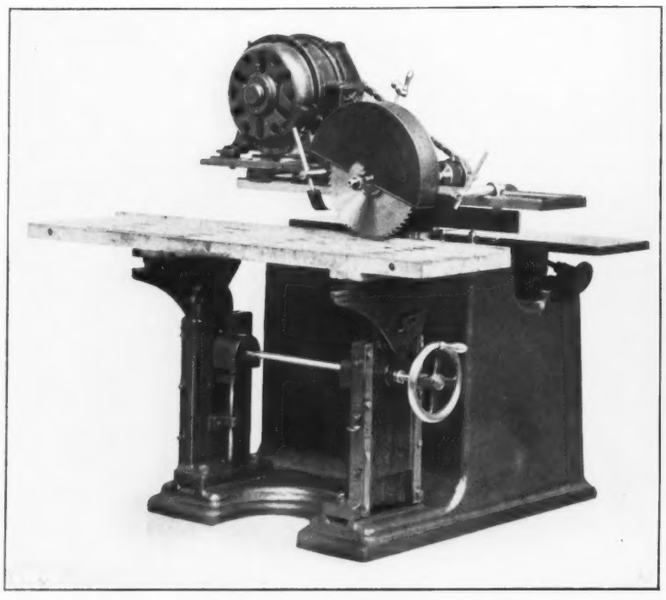


Fig. 3. "Super-Elliot" Woodworker as Rip Saw.

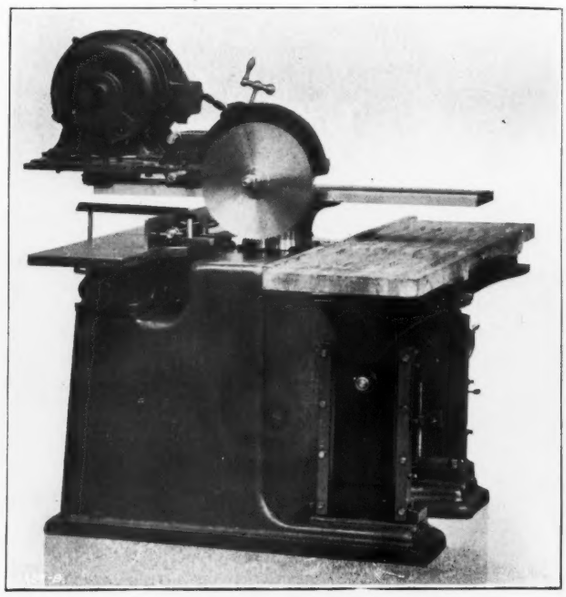


Fig. 4. Cross Cutting with "Super-Elliot" Woodworker.

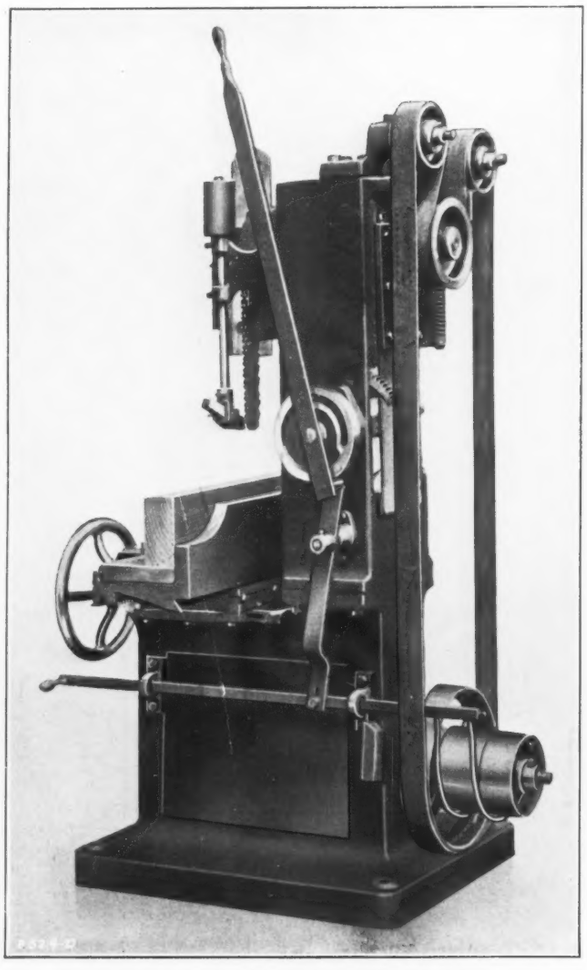


Fig. 5. Mortising Machine Showing Drive.

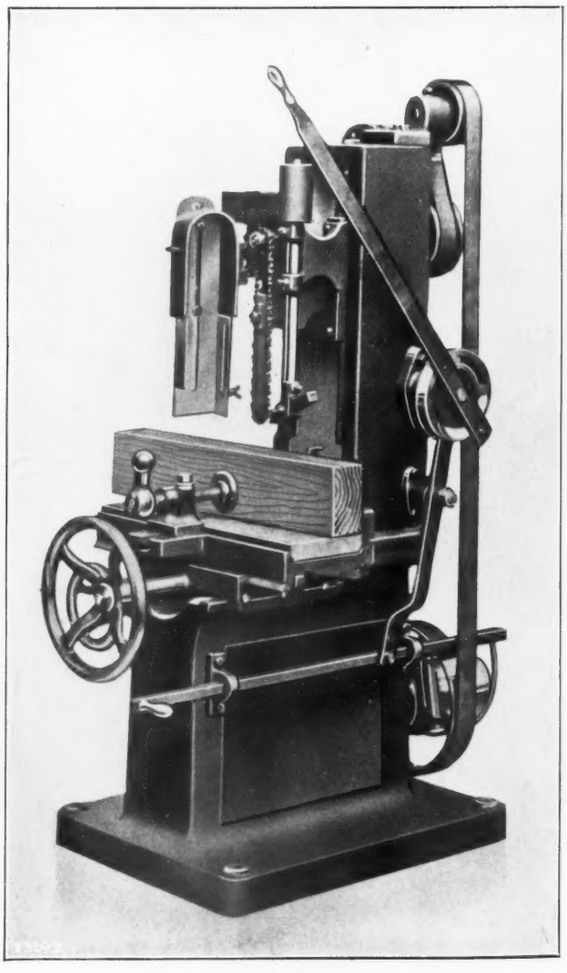


Fig. 6. Chain Type Mortising Machine.

(*To face page 553.*)

that the Colony should participate, but left the scale to be settled on the return of the Prime Minister, who was then absent in England. The journey took nearly a year, and when it returned the whole of the principal Dominions of the Empire were definitely engaged in preparations for making the exhibition as adequate as possible to the great purposes it had been established to serve. No visit was paid to India, for on the wise and practical representations of Sir William Meyer, the High Commissioner, its participation had already been decided.

It is perhaps needless to add details of the stages by which the adhesion of the other colonies and protectorates was determined. It may, however, be mentioned that, when it was found impossible for Major Belcher to visit the West Indies after leaving Australia, the Hon. F. M. B. Fisher consented to go in his place, and in some colonies as the result of his visit, and in others by independent and previous decisions, the amounts that had been voted for the Exhibition were substantially increased. The net result of these proceedings has been that practically every single territory in the Empire is now taking its part in the exhibition, which is accordingly a completely representative stocktaking of its peoples and their products.

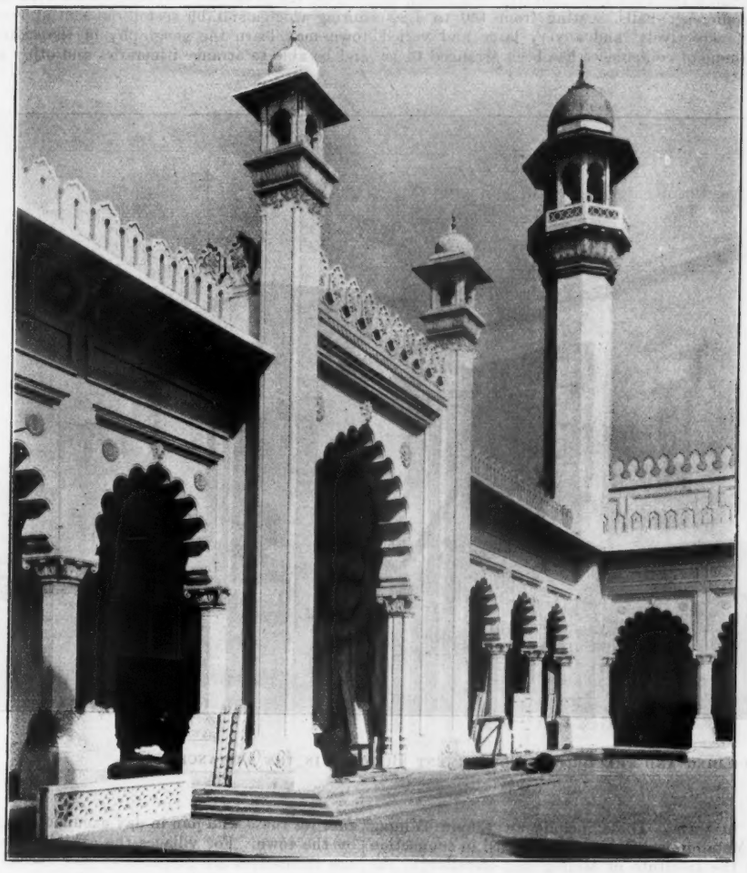


FIG. 6. INNER COURT OF THE INDIA PAVILION.

This summary account, which gives only the essential stages in the evolution of this exhibition, shows unmistakably that the conception did not, as often happens, begin on a large scale and become limited by circumstances as preparations went on; but that on the contrary it expanded at every fresh conference at which it was considered. Before the war it was proposed simply as a collection of Imperial products, on much the same scale as has been seen in many other exhibitions. The war wholly destroyed the scheme and the several years' work that had been spent on it; yet no sooner was the war over than it revived, and took on the further character of an effort of Imperial co-operation in the work of peace, as a memorial of the triumphant Imperial co-operation which had been among the few gains of the war. With this enlargement of its scope the feeling grew that its scale must be greater than had been known previously. To attain in practice the results that had been approved so unanimously in all parts of the Empire, it was then recognised that a still closer co-operation was necessary, and a still wider scope.

However much all its constituent States agreed in desiring the results that it was the desire of the participants to achieve, those who were best able to judge admitted frankly that the citizens of these States had no such accurate knowledge of each other's ways and conditions of life as was necessary if the desired effects were to be permanent. To the two main purposes of the Exhibition was therefore added a third. The exhibition had to be so arranged and conducted as to lead the citizens of the United Kingdom and those of overseas Britain to a more intimate knowledge of each other. As the foundation of such mutual knowledge it was decided that the exhibition should deal with methods of advancing the well-being of all the States of the Empire by the promoting of scientific knowledge, public health and social welfare; and an important step to the desired intimacy of association will have been taken if the exhibition leads to closer co-operation between all parts of the Empire in these universally important subjects.

The evidence of every one of the great Dominions concurs in showing that each of the three purposes has been in their minds in deciding on the magnificent scale on which they are participating in the exhibition. No view of their action would be complete or correct which did not take account of all these purposes. The vast expense and energy that have been spent on the preparations for the exhibition are perhaps the least of the reasons that should urge those who take part in it to have its full object in mind. Even more than the United Kingdom the fortunes of the overseas States are in flux. Before another such opportunity occurs of comparing notes and taking action on them the resources and needs of those States are likely to have grown faster even than they have grown during this century.

The older of the Dominions are by race purely British communities. Australia, for instance, claims that over 98 per cent. of her citizens are of direct British descent, and the percentage of New Zealand is even a shade higher. They are in effect pure British communities, established on the other side of the world. Their language, their political institutions, their traditions, their fundamental standards of mutual relations are essentially the same as those of the United Kingdom. In their territories lie unbounded natural resources, now largely sterile. The chief material interest of the Dominions is to develop those resources; and, large as is the extent to which most of them already need the manufactures of other countries, it is trifling compared to what it must become as they proceed in this development. The United Kingdom, as they believe, has the manufactures, enterprise and accumulated capital that this development requires, and a surplus population, of all races the most acceptable to them, which could find ampler accommodation and opportunity in the sparsely populated Dominion territories. The citizens of the Dominions have in their blood the British conservatism that sticks fast to its traditions; but they have also the British common sense that will not be led by sentiment to defy economic or other insuperable forces. The Dominions and Colonies that are not of purely British race have similarly adopted their place in the Empire, and, as the experience of the war showed, bear willingly their share of the common burden, without further reward than their share of the common privilege. An essential part of the task of the exhibition and the activities to be associated with it is to find means for strengthening that privilege and making it permanent.

For the time being the Mother Country and all the overseas States, producing between them practically all varieties of material commodities that man can use, are seeking how to fertilise what they have and to exchange it for what they have not. The exhibition is their opportunity for concerting plans whereby this mutual exchange may be promoted within the Empire itself, and all parties see in the possibility of such exchange the best hope of preserving throughout the States, whose assets are here brought to a stocktaking, the British traditions by which at present the Empire is cemented. The most obvious use of the exhibition is doubtless to suggest how to obtain enlarged immediate orders and sources of supply. But its greatest opportunity is to set up a mechanism between the exhibiting States, if such can be devised, that will make the exchange not merely immediate but permanent, and lead it to grow continuously in a beneficent circle.

In the above description, as indeed in all that has been written about the exhibition, stress has been laid on the large scale on which the overseas States are represented; for instance, by the unprecedented size of their pavilions, some figures of which have already been given in these columns (p. 225 *ante*), and others will be found below. This stress is amply justified; and perhaps as good a way as any to suggest the true scale of the entire exhibition is to record the fact that, great though is the aggregate area occupied by the buildings of all other States, the United Kingdom buildings by themselves cover an area about twice as large. We have already given a particular account of the construction of the great Palaces of Engineering (p. 263 *ante*) and Industry (p. 291 *ante*), and will describe some of their contents in this and subsequent issues. Now we continue the account of the genesis of the exhibition by giving some particulars of the co-operation that has been used to collect the exhibits. For with the exception of a few trades, the firms who constitute the really important industries have come into the exhibition co-operatively to an extent that has hitherto been unusual.

Thus in the Palace of Engineering the shipbuilding, marine, mechanical and general engineering

exhibits have been organised by the British Engineers' Association, electrical and allied engineering by the British Electrical and Allied Manufacturers' Association, water and land transport by special committees, motors and cycles by the Society of Motor Manufacturers and Traders in co-operation with the British Cycle and Motor Cycle Manufacturers and Traders' Union, and a joint committee of the non-ferrous metal trades with the assistance of seven trade associations have organied a comprehensive exhibit, showing in copper, brass, nickel-silver and their alloys, both the primary products of the mills and the chief uses to which they are put. The British Engineering Association have also placed at the disposal of the National Physical Laboratory a space of some 1,500 sq. ft., in which are displayed a collection of machines, apparatus and samples illustrating the applications that have been made at the laboratory of physical sciences to the practical solution of engineering, metallurgical and shipbuilding problems. In addition the Power House itself, of which we have already given a detailed description (March 14 and following issues) is a most comprehensive collection of generating plant and indiarubber, gutta percha and balata, organised by the India Rubber Manufacturers' Association.

A still more exhaustive co-operation is to be found in H.M. Government Pavilion, to the size and construction of which reference was made on p. 228 *ante*. In this is to be found exhibits by 22 Governmental Departments or establishments, in addition to exhibits dealing with the progress of pure science (organised by the Royal Society at the request of the Government) and with health in the tropics. Some departments, such as the Department of Scientific and Industrial Research, are also represented elsewhere in the exhibition. This collective Government participation discloses a volume and scope of work much in excess of what is often credited to Government departments, and should not only convey information to those who live in this country but be suggestive to overseas visitors. As a whole it is likely to be among the most interesting features of the Exhibition.

Adjoining the Palace of Industry is a group of four conference halls, seating from 120 to 1,800 people respectively, and a very large and varied programme of conferences has been arranged to be held in them. These include an Empire Mining and Metallurgical Congress, organised in connection with the Institute of Mining and Metallurgy, the Institution of Mining Engineers, the Institution of Petroleum Technologists, the Mining Association of Great Britain, the Iron and Steel Institute, the Institute of Metals, and the National Federation of Iron and Steel Manufacturers; the first World Power Conference; and the International Advertising Convention. The Power Conference, which has been initiated and organised by the British Electrical and Allied Manufacturers' Association, has grown into a widely supported international convocation. The programme has been settled with the co-operation of representatives of the British Admiralty, War Office, Air Ministry and Research Department, as well as of the Institutions of Civil, Mechanical and Electrical Engineers, the Society of Chemical Industry, the Association of Mining Electrical Engineers, the Federation of British Industries, the National Gas Council, the Institution of Gas Engineers, the British Electrical Development Association, and the British Empire Producers' Organisation. The conduct of the conference, which is to be held from June 30 to July 12, will be in the hands of an International Executive Committee, on which all the participating countries will be represented, and its proceedings will be published after the conference in book form. Almost immediately after the Conference official tours will be undertaken to places of interest in Great Britain, France, Italy, Switzerland, Norway and Sweden. There are many other conferences of interest to engineers, besides a considerable number that may not be.

A fine Civic Hall, architecturally in keeping with the main exhibition buildings, has been provided with the sagacious design of attracting authorities and inhabitants of provincial cities and towns, The primary intention is to use it for a series of "civic weeks" or short periods, during which the accommodation of the hall and its offices will be reserved for the authorities of the city that has bespoken it, which will make intensive propaganda in relation to its principal industries. For towns that cannot afford the expense of a "civic week" it has been arranged to reserve office accommodation for the week they may select and a week earlier, during which a suitable secretariat sent up from the town may learn the geography of the exhibition and be able to arrange itineraries and other assistance for those who join in day excursions organised by the town. For villages the exhibition authorities themselves are prepared to give special assistance to organisers who propose to bring a combined excursion on a given day, which will be named after the village in question. This enterprising programme should be useful both to the exhibition and to the visitors. As a means of learning something about the Empire with a rapidity and precision that could not be had otherwise the exhibition offers an opportuuity that may never occur again, and certainly not for many years.

By the side of the Palace of Industry is the Palace of Arts, a smaller building in the same style, standing on some 60,000 sq. ft. of ground. The contents of this building, though drawn predominantly from Great Britain, include also contributions from overseas, to which a separate range of galleries is devoted. The lighting is arranged for the most part through clerestory lanterns, which, with the help of deep coves and whitened ceilings, give a large proportion of indirect light, and the resulting illumination is exceptionally uniform and free from shadows. Double walls of framed breeze slabs are used, which served to shorten the time of erecting the building. and provide insulating effect. As shown on the plan Fig. 1 on page 524

FIG. 7. NEWFOUNDLAND BUILDING AND THE BRITISH GOVERNMENT BUILDING IN THE DISTANCE.

and equipment due to the co-operation of a large number of independent forms.

Similarly the Palace of Industry has its exhibits arranged in 23 groups, of which all but two (glass and domestic utilities and fancy goods) have been organised either by one or a combination of trade associations or by a special committee. The chemical, dyestuffs and perfumery industries, including soap, for example, have been organised by the Association of British Chemical Manufacturers on a ground space of nearly an acre, and the comprehensive character of the exhibit is well illustrated in the form of a frieze painted by Mr. Cosmo Clark, which beautifully and instructively shows a considerable number of typical operations in chemical manufacture. This group of exhibits has likewise found accommodation for the chemical part of the exhibits in pure science prepared at the request of the British Government by the Royal Society. Among other groups of special interest to engineers are those of clocks, watches, jewellery and cutlery, organised by a special committee; the British gas industry, organised by the National Gas Council, the British Commercial Gas Association; the Institution of Gas Engineers and other bodies, building materials, heating and ventilation and scientific implements, organised by special committees;

THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 528.)

Fig. 8. The New Zealand Pavilion.

Fig. 9. The Union of South Africa Pavilion.

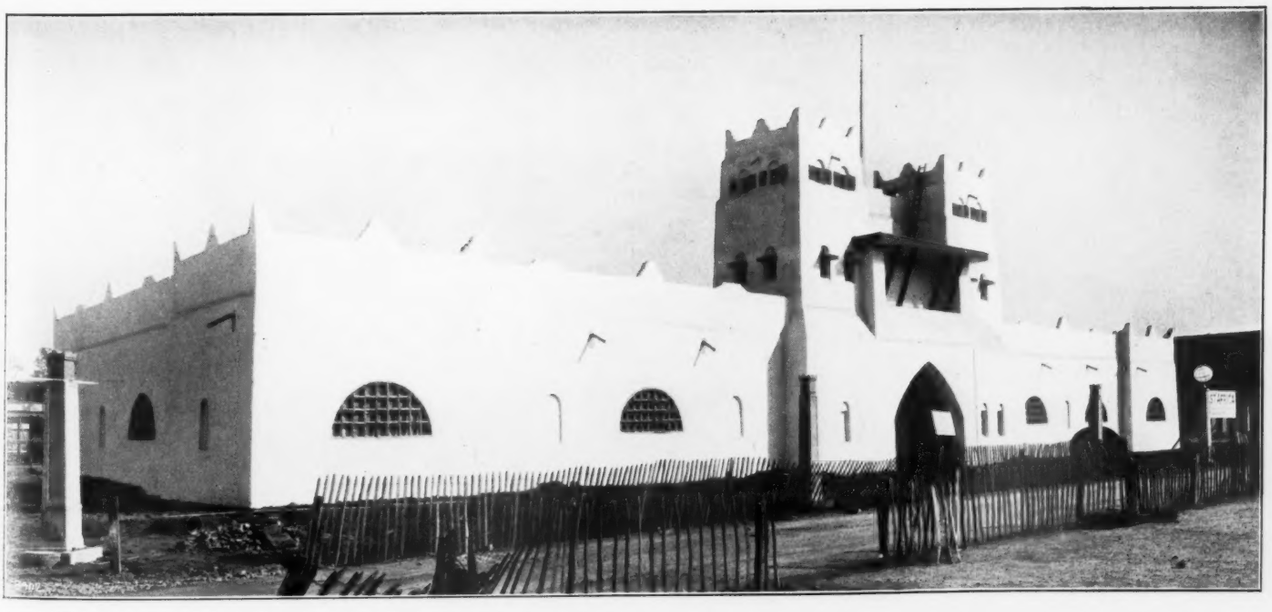


Fig. 10. The East Africa Pavilion.

(*To face page* 526.)

THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 528.)

FIG. 11. THE CEYLON PAVILION.

FIG. 12. THE WEST INDIES PAVILION.

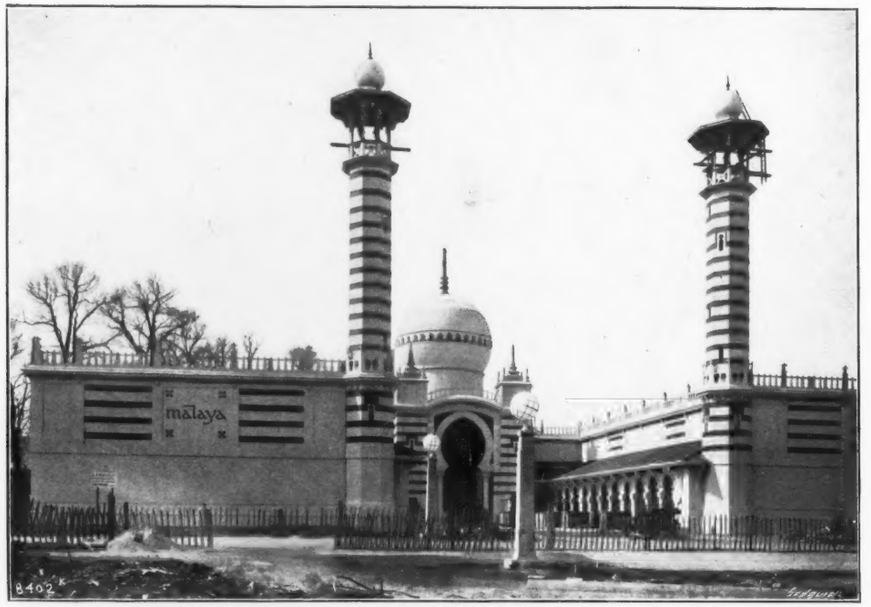


FIG. 13. THE MALAYA PAVILION.

FIG. 14. THE MALTA PAVILION.

(*To face page* 527.)

THE BRITISH EMPIRE EXHIBITION; COMMERCIAL AND MILITARY AEROPLANES.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, WEYBRIDGE.

(*For Description, see Page* 550.)

FIG. 3. "VANGUARD" COMMERCIAL AEROPLANE TO CARRY 23 PASSENGERS.

FIG. 4. "VALPARAISO" MILITARY TWO-SEATER AEROPLANE FOR RECONNAISSANCE WORK AND BOMBING.

(*To face page* 550.)

THE BRITISH EMPIRE EXHIBITION: 400-H.P. BRISTOL "JUPITER" AEROPLANE ENGINE.

CONSTRUCTED BY THE BRISTOL AEROPLANE COMPANY, LIMITED, ENGINEERS, BRISTOL.

(*For Description, see Page 550.*)

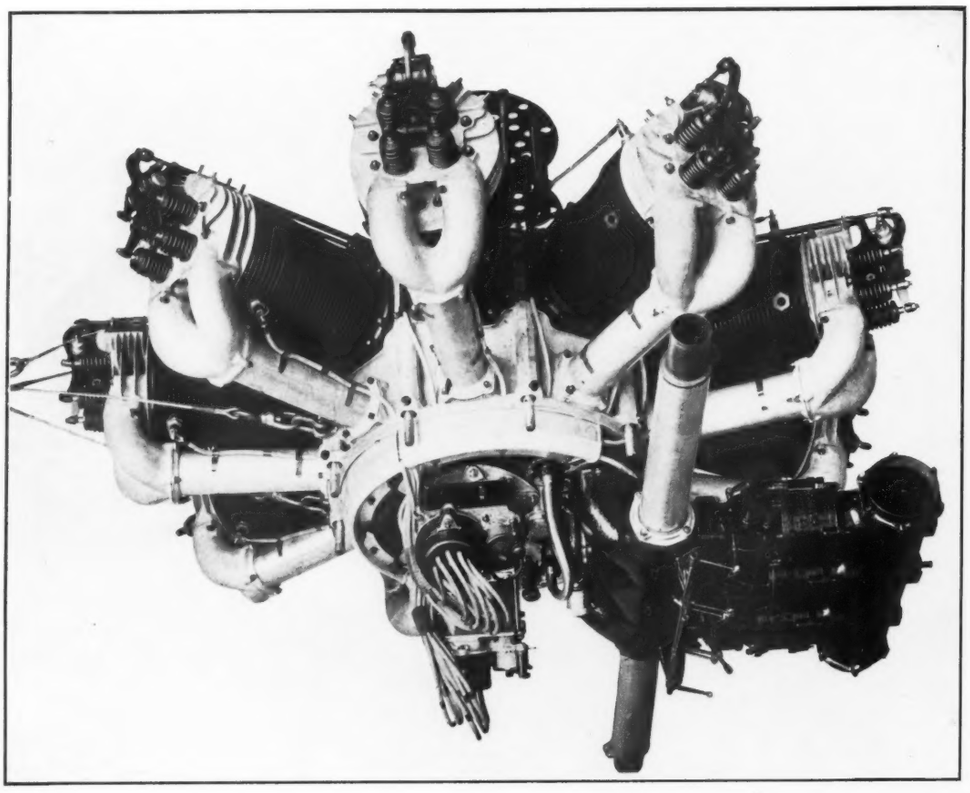


Fig. 6. Rear View of Engine.

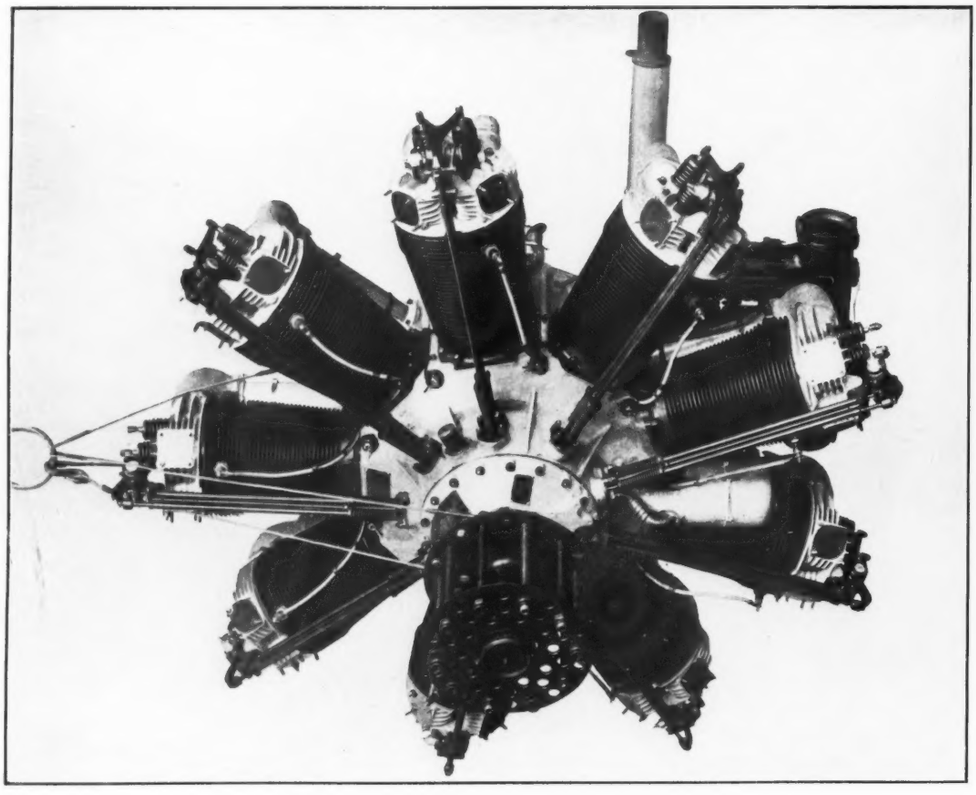


Fig. 5. Front View of Engine.

(*To face page 551.*

the line of the south faces of the three Palaces forms the base of a shallow circus, through which runs the artificial lake, at the east and west ends of which are the sections devoted to India and New Zealand, and along its south boundary those of Canada and Australia, behind which lies the Stadium with its considerable buildings at the highest point of the exhibition. The Burma section adjoins that of India, the South African section lying along the same line near the south boundary of the Exhibition, with Malta, East and West Africa and Palestine and Cyprus between the L. & N.E. (G.C.) line, with its Exhibition station, runs in a curve along the east faces of these sections, the Ceylon and Hong Kong lie to the east on the south boundary of the exhibition, British Guiana, the West Indies, the British Government building, Newfoundland, and Fiji lying on a line due north from the Hong Kong section, and abutting on to the south part of the Amusement Park. The sections of Malaya and Sarawak lie between the south-west entrance of the Exhibition and the New Zealand section.

The Indian section (Figs. 2 and 6) represents the co-operation of the Government of India, who are devoting some 180,000*l.* to the Exhibition, with the indeed, purporting to reproduce any one building, but embodying in a singularly beautiful and impressive whole a variety of ornament of which every detail is actually based on some existing original. The main entrance is surmounted by a dome 37 ft. in diameter and flanked by minarets 110 ft. high. The white marble of the originals is reproduced in fibrous plaster, used as a facing to steel structures lagged with timber for the towers and heavier work, and timber structures for the minarets and other lighter detail. The interior of the pavilion is arranged in 27 sub-sections, devoted respectively to the many products and natural resources of the country, with exhibits showing both the development of ports and the remarkable fullness and accuracy with which the country is being surveyed in every aspect. The products include some that are made in factories, such as cotton and woollen fabrics, jute, resin, turpentine, and chemicals, leather, and iron and steel; but while sufficient to be representative of what is being done, these exhibits are small relatively to those of raw materials —jute, wool, cotton, timber, minerals, tea, and many more—and of the cottage industries traditional throughout the country.

or the Australian Pavilion that it adjoins, though otherwise observing the same exclusion of trivial ornament as characterises those buildings, and is appropriate to the great frontages involved. The main building (Plate XXXV) has a frontage of about 400 ft. by a depth of 200 ft., and is flanked by buildings of about 100 ft. and 60 ft. frontage, with a depth of about 100 ft., which accommodate exhibits from the Canadian National Railways and the Canadian Pacific Railway respectively. These are all built of Canadian timber faced with fibrous plaster, and stand in grounds of nearly 6 acres. The entire exhibit is put forward by the Canadian Government, through whom both the Provincial Governments and private firms act; the Government, in fact, for a nominal charge, has undertaken the cost of freight, provision of stands and general dues for individual exhibitors. In this way it has been able to assure a full and representative collection of exhibits. These cover the Dominion's immense agricultural industry, the many varieties of timber in its forests, and specimens from practically every producing mine. An important section is given to industrial manufactures, in which the Dominion's policy appears to be to encourage the

FIG. 15. THE HONG KONG BUILDING.

Provincial Governments, who are contributing a further 125,000*l.*, and the Native States, to whom have been allotted one-sixth of the total available space, and whose Princes have joined in the enterprise with the enthusiasm and splendour that characterises their participation in any Imperial movement. The importance of the Exhibition to India was warranted very cogently to those most concerned in her welfare by the keen interest with which the project was supported from the outset by the late Sir William Meyer, the first High Commissioner, who in Indian and Anglo-Indian circles was known not less for his single-minded and even passionate devotion to the service of India than for the financial and administrative ability on which his reputation with a wider public was based. The organisation of the exhibits has been made by the Government of India. Their Exhibition Commissioner, Diwan Bahadur Vijayaghava Charya, was appointed over two years ago, and both in this country and in India has been working incessantly ever since, with the continued support of the present High Commissioner, Sir Dadiba Dallal. The section occupies just on 5 acres, of which some 3 acres are covered by buildings Fig. 2, arranged round a courtyard 150 ft. square, with an ornamental water in the centre Fig. 6. The design of the buildings, which was made by Sir Charles Allom, is purely Indian, not,

Burma is spending 40,000*l.* on its section. It is housed in buildings, designed by Mr. Adams Acton, in purely Burmese style (Plate XXXIV), with the main body constructed of steel with breeze slabs to carry the fibrous plaster facing and decoration, and spires in steel lattice work timbered and covered with roborite to take decorations that have been carved in Burma out of Burmese teak. The elaborate and extensive carvings with which the building is enriched give them a decorative effect that attracts and can stand close examination, and the grounds are laid out in Burmese style. The exhibits relate mainly to produce, timber, oil products, minerals, and the working of lacquer, silver, ivory, bronze, and so forth, that is done in the cottage industries. Of these the produce, timber, and minerals are by far the most important, and represent resources with wide room for development and expansion. Models are included of a rice mill and a mine, and a plant is shown in the grounds to illustrate how Burma oil shale is treated.

Canada, which was among the first of the Dominions to decide on entering the exhibition on a large scale, has produced by far the largest exhibit of the many that she has organised. The architect of the buildings in which it is housed, Mr. J. O. Turcotte, has adopted a somewhat more ornate style than that of the British Palaces which it faces,

establishment of branch works in Canada, rather than the import of products from other countries.

The Australian Pavilion (Plate XXXV) stands in grounds of about the same size as those of Canada, laid out in gardens with Australian plants and flowers, and has a frontage of about 700 ft. by a depth of about 175 ft. It is built to the designs of Mr. G. J. Oakeshott, in timber faced with fibrous plaster, and in style harmonises well with the Canadian building and the two opposite Palaces, the latter of which it somewhat resembles. Its accommodation includes a cinema theatre, in which the life and industries of Australia are being shown continuously, in addition to dioramas, working models and other striking illustrations of its typical industries, agriculture, pastoral production, refrigerated products, fisheries and marine products, wines, minerals, and miscellaneous manufactures. One for which the general public may not be prepared is a diorama showing a cotton field and ginning plant, representing a quite recent industry, producing cotton of the highest class to nearly 20 times the extent that it produced two years ago, and with the possibility of becoming as great as the wheat industry.

The New Zealand Pavilion (Plate XXXVI) near the west boundary of the Exhibition, opposite the Indian section at the east end of the lake and central

avenues, has a frontage of some 450 ft., covering about an acre of ground, and surrounded by about two acres of gardens, laid out with New Zealand trees and shrubs. While retaining the simplicity of line that characterises the buildings to each side of it along the avenue, it is distinguished by a deep frieze enriched with bas-relief panels in fibrous plaster carried on columns, which depict various phases of New Zealand life. In the interior a main hall, decorated with Maori carvings and a frieze painted by New Zealand artists to illustrate the natural features and principal cities of the islands, exhibits along each side the attractions of the country to the tourist, sportsman, and naturalist, and at the end, the timbers of the country in all stages of work. In the south side, a central dome displaying the processes of sheep shearing and the very numerous types of fleeces is surrounded by exhibits illustrating secondary manufacturing industries, minerals, grains and seeds, Kauri gums and similar products, with a cinema theatre at the end for the purpose of further exposition. The north side is devoted to meat, furs, fish, fruit, and dairy products, preserved in refrigerated chambers. In the south end of the grounds is a Maori house, copied from one built by a native chief in memory of his ancestors, which here contains objects of historical Maori interest, and at the north end a Samoan erection (Samoa being now administered by New Zealand) copied from one built by the chief Mataafa at Apia, containing native exhibits relating to the history and fauna of the island. The entire section is the exhibit of the New Zealand Government, who bear all expenses and make no charge for space.

The South African building (Plate XXXVI) is of an old Dutch style, with gables, stoep and loggia. With a frontage of 425 ft., it covers over an acre of ground, and is surrounded by nearly 4 acres of grounds, laid out as gardens with South African plants, an ostrich paddock, and a dining-car from the South African Railways, where meals are served as in that country. The raw materials and products exhibited include diamonds (with a complete working model of a washing plant and demonstrations of cutting and polishing), and other minerals, wool, mohair, ostrich feathers, fruit, wines, dried fruits, canned fruits, and manufactured goods. Special stands represent Rhodesia, Tristan da Cunha, Swaziland, and Bechuanaland; Capetown and Durban show their harbour facilities; and two separate cinemas deal respectively with Government and individual exhibits. An important part of the exhibits are devoted to drawing the attention of tourists to the great variety of attractions and climate to be found within the Union.

With a 75-ft. frontage, standing in grounds of 27,000 sq. ft., the Newfoundland Pavilion (page 526) is a happy example of the simplicity and dignity of style that characterises the several British buildings. The industries represented are fishing, mining, timber, game and inland fish, agriculture and wild fruits, and a great variety of furs and pelts. Working models are shown of falls used for water-power, and of cod-liver oil manufacture, and there is an extensive exhibit of forest products, including "newsprint."

South of the British Government Pavilion is a building in the Colonial Georgian style with a frontage of about 175 ft., Plate XXXVII, on a site of two acres, with the grounds laid out as a tropical garden. This is divided between the exhibits of the West Indian and Atlantic group of colonies, including Jamaica, Trinidad, Tobago, Barbados, the Bahamas, the Windward, Leeward and Falkland Islands, and British Honduras, with the south wing occupied by British Guiana. Among the most striking exhibits are models of the pitch lake near Trinidad and of the Kaieteur Waterfall in Guiana, with a working model of an alluvial gold and diamond pit. On the south boundary of the Exhibition, lining up with the Government and West Indian Pavilions, is the Hong Kong exhibit, formed as the reproduction of a Hong Kong street about 100 yards long (page 527) in about 1¼ acres of ground, with native population and an actively working reproduction of a Chinese restaurant. The exhibits proper include models of the docks and of steamships built there, with native shops in which the making of carved woodwork, silver filagree, and embroidery will be carried on. Immediately west of this is the Ceylon Pavilion, with a frontage of 150 ft. (Plate XXXVII) in an area of over an acre. The building is in the remarkable Kandyan style, with towers designed on the lines of a famous Kandy temple, and the most important of the exhibits relate to tea and rubber. A small exhibit—though it stands in a quarter of an acre of ground—illustrates the products of Fiji.

A picturesque and interesting group of sections lie north of South Africa, east of the Stadium, and south of Burma and Canada. The Malta Pavilion, Plate XXXVII, in half an acre of garden, covers about 3,000 sq. ft. to 4,000 sq. ft., and is remarkable for its architecture in the military style of the 14th century, when the island was held by the Knights of St. John of Jerusalem, with reproductions of ancient gates. The interior is devoted largely to the artistic exposition of the history of the island. The exhibits include the beautiful Malta limestones, of which the deposits are very large—it is used in the construction of parts of the building—with working exhibits of filagree and other gold and silver working, and lace and cigarette making. Next to it stands the East African section, Plate XXXVI, in about an acre of ground, typifying an Arab palace, of about 180 ft. frontage, within which are Courts representing Kenya, Sudan, Uganda, Zanzibar, Nyasaland, Mauritius, the Seychelles, and the mandated Territory of Tanganyika. The main entrance door is a remarkable piece of carving, copied by native workmen from a famous original. The original Arab buildings are of coral whitened over, and the fibrous plaster in which it is here reproduced is accordingly conspicuous by its expanse of pure white. The produce of each colony is represented, with models illustrating such works as the dams in the Sudan, by the help of which it is hoped to grow cotton on a larger scale.

An even more striking reproduction is a walled city enclosing three acres of ground, the wall being built in timber with a plaster screen on metal lathing, to resemble the West African mud walls (Fig 16). Within are buildings devoted to the Gold Coast, Nigeria, and Sierra Leone, with a West African village occupied by natives from a variety of tribes. The Gold Coast building is from a design by Messrs. W. Bruce Smith and E. J. Humphries, based on that of the castles erected at intervals for the purposes of the slave trade, with doors carved in the Colony out of African woods. The Gold Coast exhibit, displayed panoramically in seven courts, includes cocoa, manganese, and a variety of native crafts in actual operation, including various stages in the diamond industry. Among the Nigerian exhibits, which include the considerable varieties of its produce—nuts, hides, tin, gold, coal, rubber, cocoa, timber—will be a complete oil extraction plant in operation. The Sierra Leone exhibits will be similar, with special stress on the variety of timbers produced. South of the walled city the pavilion of Palestine and Cyprus, standing in half an acre of ground, represents the industries of the colonies, and in particular serves their wines in a verandah café. To the west is the Bermuda pavilion, devoted mainly to illustrating its climate, sporting attractions, and history.

Adjoining New Zealand in a line with Australia is a Moorish-Arabesque Pavilion devoted to Malay and the Straits Settlements (Plate XXXVII) and next to it a smaller one for Sarawak (Fig. 17) modelled on the residence of the Rajah. Rubber and tin are the subjects of the principal exhibits.

Many interesting exhibits are to be found in the grounds, and space does not allow even a catalogue of the variety of side-shows and restaurants. The walls of many of the restaurant buildings are constructed with breeze blocks faced with Keene's cement and decorated by art students from various centres. Behind the east face of the Palace of Engineering is a realistic reproduction of a coal mine. In addition to the "Never-stop" railway already briefly dealt with (page 225), which runs from the main (N.) entrance round the east side of the Palace of Engineering, a "road-rail" runs along most of the south boundary of the exhibition, with petrol cars mounted on bogies which run on a 2-ft. gauge line, the driving-wheels of the cars running on pathways on either side of the line. The photographs from which our illustrations of the building were prepared are by Messrs. Campbell-Gray, Limited, of 88, Edgware-road, London.

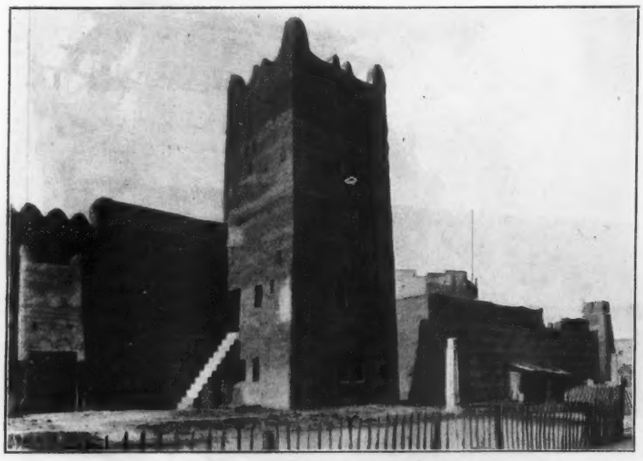


FIG. 16. THE WEST AFRICA WALLED TOWN.

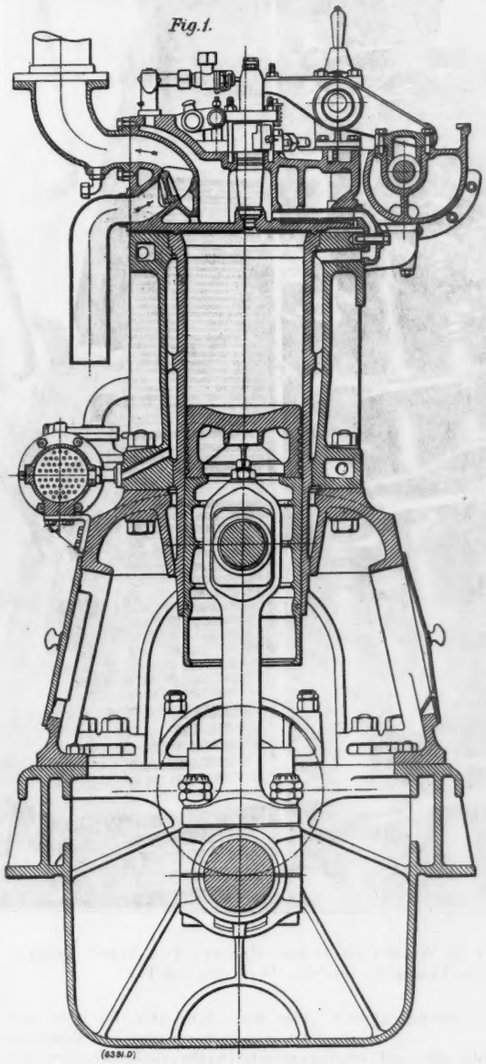
FIG. 17. THE SARAWAK PAVILION.

EXHIBITS IN THE PALACE OF ENGINEERING.

Having given some idea of the initiation, constitution and structural features of the Exhibition we propose by means of a number of illustrated examples to attempt to indicate something of the remarkable collection of material which is to be seen in the Palace of Engineering. We naturally choose to confine this, our first notice of the exhibits, to those of an engineering nature, but a number of the buildings other than that devoted to engineering contain exhibits likely to be of interest to our readers, and many of these we hope to deal with in later issues. Even with the limitation which we are imposing in connection with our present notice, it will be evident that we cannot pretend to deal with more than a very restricted selection from the abundance of engineering material which has been brought together, and while we have endeavoured to cover a reasonably representative range many very important exhibits will be found to have been neglected for the moment.

Any illustrated description of matter shown at the Exhibition, published within such a brief period of the opening, is naturally subject to the limitations of time, and while a great effort has been made to assemble a series of descriptions which will give a proper idea of the extent and importance of the Wembley display from the point of view of the engineer, any notice of the products of many of our important engineering firms has had to be postponed to a later date. We have endeavoured to make this number illustrative of most of the important branches of engineering rather than illustrative of the activities of the more important British firms. The actual selection of any firm or firms to furnish the matter illustrating any particular branch of work has mainly been determined by our actual possession of the detailed information necessary for the preparation of our description, but even with this limitation we think this Exhibition Number will give a proper idea of the extent, variety and importance of this great display of the products of the engineering firms of the Empire. To some degree the products of some of our great firms has already been covered by our earlier articles on the Palace of Engineering and Industry and on the Power Station, which ran through our issues from February 22 to last week. This earlier matter and our present descriptions make up a very comprehensive collection of descriptions, but even so we believe we are likely to find no lack of matter for our later articles.

Fig. 1.



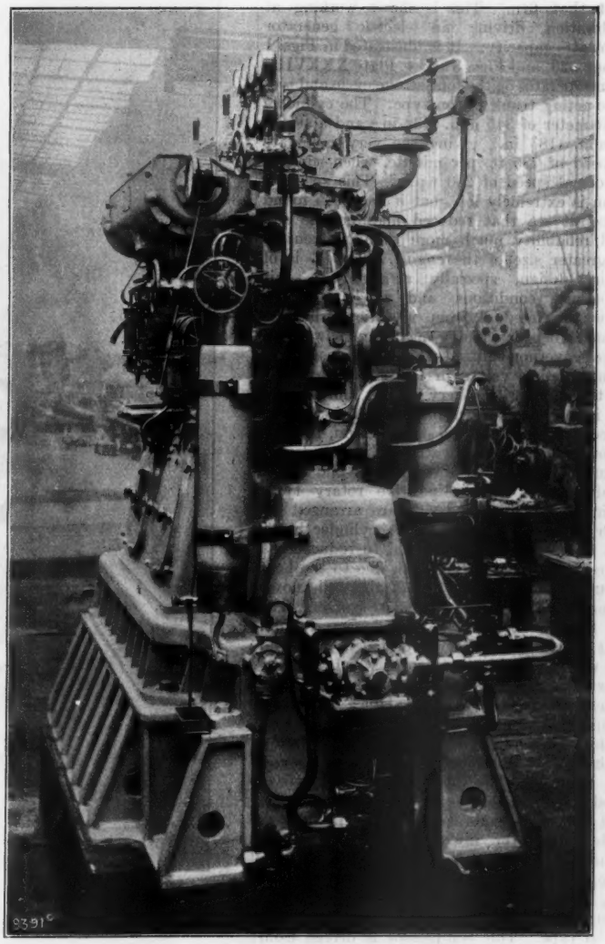


FIG. 2.

FIGS. 1 AND 2. THE BEARDMORE-TOSI AUXILIARY MARINE DIESEL ENGINE; MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, DALMUIR.

INTERNAL COMBUSTION ENGINES—I.

Although opinion must differ on what is the most important branch of engineering, there can be no question but that the internal-combustion engine represents a branch which has become of enormous importance to the whole civilized world in a remarkably short period. No great number of years ago this type of prime-mover was represented by

little more than fixed types of gas and oil engine, but its sphere has now extended to transport to such an extent that the internal-combustion engine has become the sole unit in aerial travel, one of the most important units in land transport, and is rapidly becoming of the first importance for sea travel. The internal-combustion engine, despite these remarkable advances, shows no signs of exhausting its possible field and represents such an active and advancing branch of engineering that very great interest is likely to be taken in that section of the Exhibition which it covers. A selection of exhibits has been brought together which well illustrates the breadth and importance of the subject they represent, each form of transport and many examples of fixed types being available for inspection and study.

Among the many representative exhibits the products of Messrs. William Beardmore and Company, Limited, form an important item. Great interest will be taken in a Beardmore-Tosi engine of 130 brake horse-power sent by the Dalmuir works of that firm. This is shown working at the Exhibition, driving an electric generator of 85 kilowatts capacity. It is illustrated in Figs. 1 and 2, page 529, and Figs. 3 and 4, Plate XXXVIII. The engine operates on the four-stroke cycle and is of the single-acting trunk piston type. The cylinders have a diameter of 345 mm. (13⅝ in.) and a stroke of 480 mm. (18⅞ in.), giving the very moderate piston speed of 785 ft. per minute, when running at the normal speed of 250 r.p.m. This speed of revolution is extremely low, but it has been found in service at sea that reduced maintenance and increased reliability much more than compensate for the greater size of the engine. The set is of substantial design, specially arranged to suit marine service conditions, and a characteristic feature is the freedom from vibration which is experienced when developing maximum power. A centrifugal governor is fitted which operates on the fuel pump suction valves in the usual way, and controls the speed within very narrow limits, when the load is suddenly thrown off or on.

The bedplate, which is of a deep section, forms a sump from which the lubricating oil pump draws. This pump is driven off the compressor end of the crankshaft and is of the positive rotary type. The cylinder jackets and heads are arranged for sea-water cooling. Actually these cylinder heads are of a design specially arranged to reduce to a minimum the stresses in the head, due to the heat of combustion, by the adoption of the well-known Beardmore-Tosi inlet and exhaust system. The cylinder head is fitted with the following valves: Fuel, air starting, relief and combined inlet and exhaust valves; the latter, two of which are provided for each cylinder, operate together and function alternately as inlet and exhaust, operating in conjunction with the Beardmore-Tosi direction valve, which places the cylinder space in communication with the air induction pipe or exhaust manifold, as required. The inlet and exhaust valves are fitted in removable cages and all valves are arranged for easy examination. The fuel injection valve is of the inward opening "needle" type, and is totally enclosed, being designed to eliminate packing glands with their attendant troubles. Compressed air is used for fuel injection and is supplied by a three-stage compressor of the differential type. This compressor is driven from a crank forged solid with the engine crankshaft. It is designed to give long service with the minimum of trouble under the most trying conditions, and is of sufficient capacity to supply the necessary blast air, and to allow a surplus which can be used, whenever required, to augment the ship's starting or main blast air supplies. Special and efficient inter-stage and after coolers are fitted, resulting in an exceedingly cool working compressor. Renewable liners are fitted to the cylinders in all stages. The L.P. and I.P. stage valves, which are of the flat plate type and are arranged in readily accessible positions, can be withdrawn, examined and replaced in a few minutes.

Compressed air, at the low pressure of 350 lb. per square inch, is used for starting the engine. This permits the advantage, in a marine installation, of allowing the main and auxiliary engines to use common air receivers for starting purposes. On trial this engine has been found to start with perfect ease with air at a pressure of 150 lb. per square inch. Low pressure starting air, as is generally known, is a most desirable feature, making for very much easier starting conditions in the engine cylinder and obviating the cooling effect of the great expansion of high pressure starting air. An item of interest is the type of piston packing used, which has proved very satisfactory in service. This is of a new design and is arranged to prevent pressure leakage to the back of the ordinary Ramsbottom rings, so removing conditions which are conducive to wear of the piston rings and cylinder liners.

The following are the average results obtained with this set in a four hours' trial at full power, which Messrs. William Beardmore and Co., Limited, have very kindly supplied to us:—

Revolutions per minute	250
Voltage of electricity supply	222
Amperes output	364
Kilowatts generated	80·8
Fuel used in the four hours' test, lbs....	207·1
Fuel per kilowatt-hour, lbs.	0·64
Generator efficiency, per cent.	86
Fuel per brake horse power-hour, lbs. ...	0·41

Two typical internal combustion engines are shown by Messrs. W. H. Allen, Sons and Co., Limited, of Bedford, in the form of a 320 brake horse-power Diesel engine of the Burmeister and Wain type, and a heavy oil two-cycle vertical engine of 60 brake horse-power. The latter drives a 36-kw. dynamo direct. It is illustrated in Fig. 5, Plate XXXIX, the combined generating set being suitable for marine auxiliary purposes. The engine is intended for heavy residual oils as fuel, being regulated by the governor controlling the amount of fuel injected. The two cylinders are 11½ in. in diameter, the stroke being 13 in. No water is injected into the cylinders. The main crankshaft bearings are continuously lubricated by rings dipping into oil reservoirs. The cylinders are force lubricated by a mechanical lubricator delivering at four points in each cylinder wall. The same lubricator furnishes oil under pressure to the gudgeon pins, also supplying oil to catchers attached to the crankshaft webs, from which it is passed to the large ends by centrifugal force. Engines of this type are built in sizes ranging from 15 to 200 brake horse-power. The dynamo to which this engine is direct coupled is of the Allen continuous current multipolar compound wound interpolar type for 220 volts. The speed of the set is 325 r.p.m.

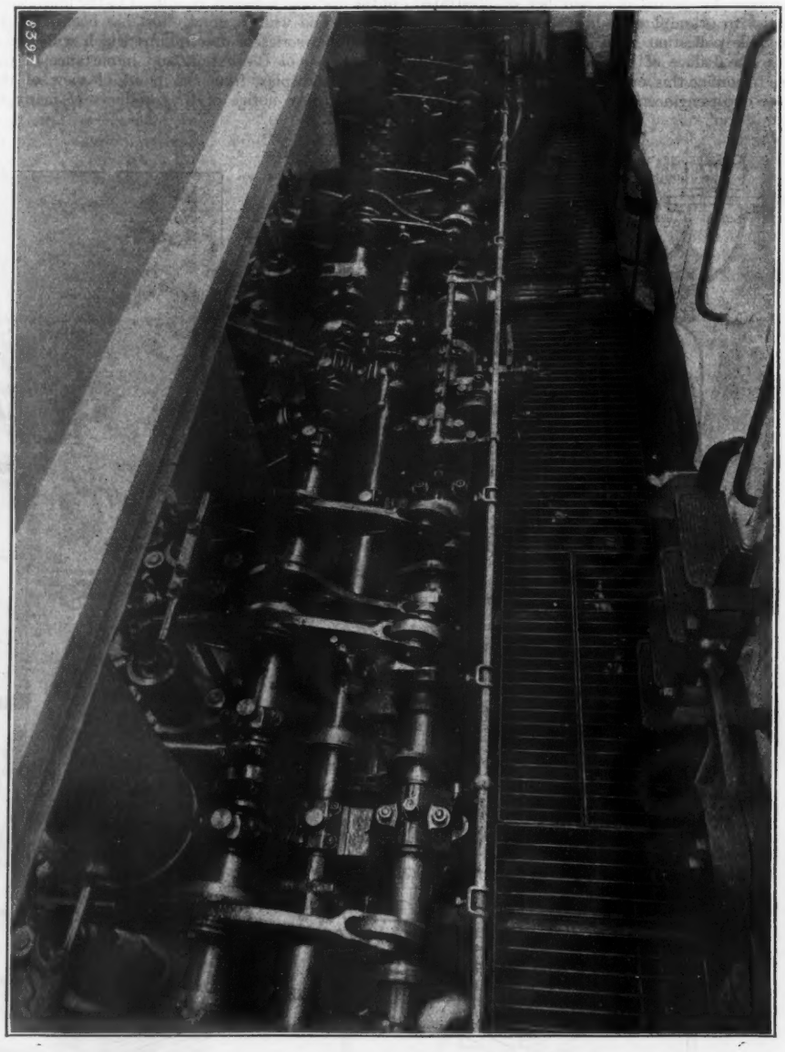


FIG. 7. VIEW OF VALVE GEAR OF WERKSPOOR DIESEL ENGINE: THE NORTH-EASTERN MARINE ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

The Diesel engine exhibited by Messrs. Allen is illustrated in Fig. 6, Plate XXXIX. It is a four-cylinder four-cycle engine running at 300 r.p.m., and having cylinders 410 mm. (16·1 in.) in diameter, and a stroke of 520 mm. (20·5 in.). The cylinders are held down by long bolts passing from the cylinder flanges to the bed-plate near the main bearings. The cylinders are made up of separate liner and jacket,

BRITISH EMPIRE EXHIBITION; 150-B.H.P. THREE-CYLINDER VERTICAL GAS ENGINE.

CONSTRUCTED BY THE NATIONAL GAS ENGINE COMPANY, LIMITED, ENGINEERS, ASHTON-UNDER-LYNE.

Fig. 8.

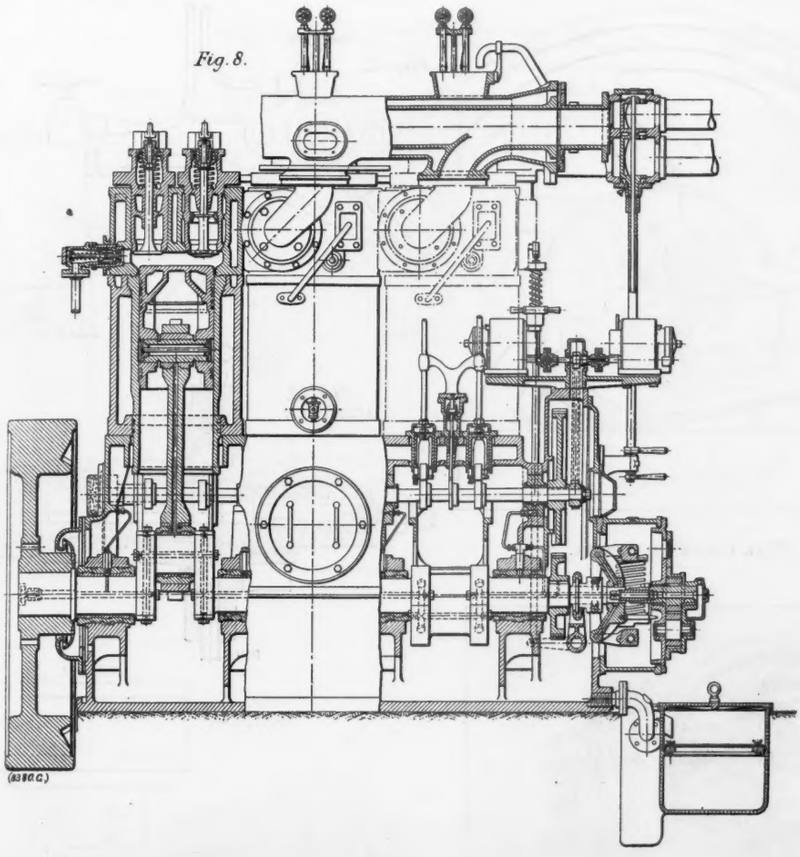
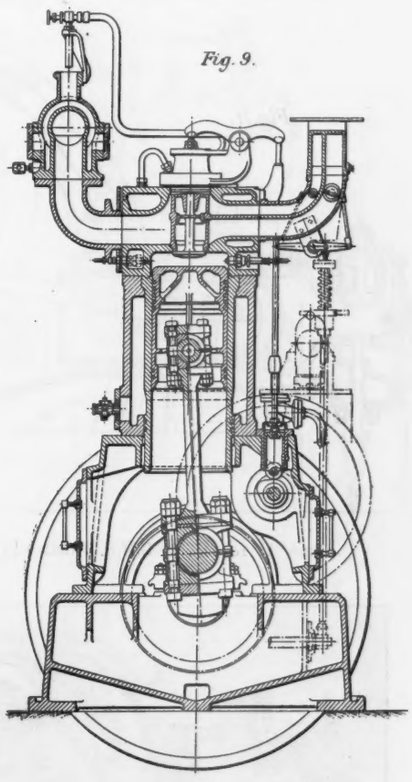


Fig. 9.



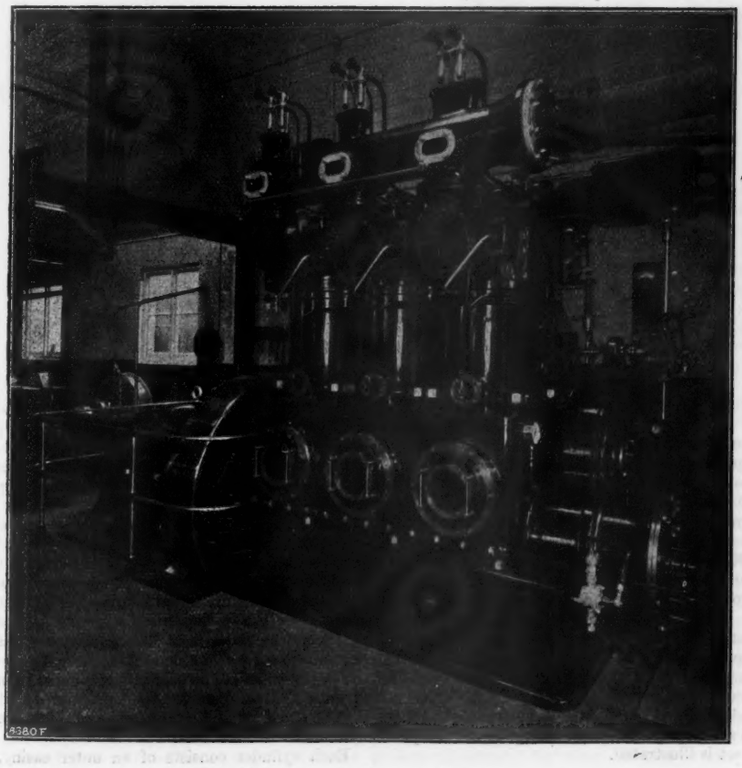


FIG. 10. GENERAL VIEW OF ENGINE.

the liners being of a special mixture, and the trunk pistons of hard, close-grained iron. The cylinder covers are carefully designed so as to avoid setting up uneven expansion stresses. They are fully water cooled and carry the starting, fuel injection, air inlet and exhaust valves. All the valves are fitted vertically and in loose boxes made of a special grade of cast iron. The valves themselves are of forged Siemens-Martin steel. The exhaust valve is made with a loose cast-iron seat easily renewable. The exhaust valve box is water cooled. The fuel injection valve opens inwards, and the oil is sprayed into the cylinder in the form of a hollow cone, so as to secure good combustion with low fuel consumption and a minimum of maintenance. Each cylinder has its own fuel pump.

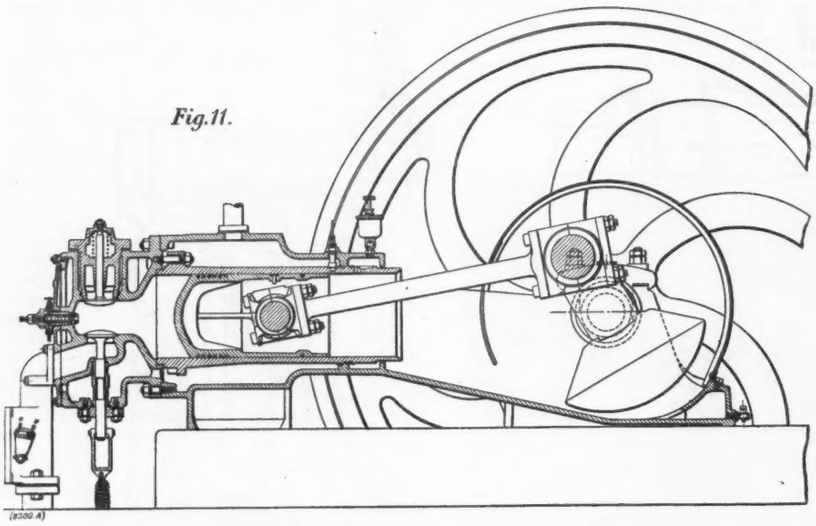
The crankshaft is a solid Siemens-Martin forging. An outside bearing is provided beyond the flywheel. The gudgeon-pins are of mild steel, case-hardened and ground. The connecting rods are Siemens-Martin steel forgings. The large end has white-metal lined brasses; the little ends are fitted with bronze bushes. Forced lubrication is supplied to all main bearings, connecting rods and pistons by means of an oil pump, on the closed sight-feed principle. The same pump supplies the air compressor. The pistons are oil cooled, circulation being secured by a pump connected with the crankshaft.

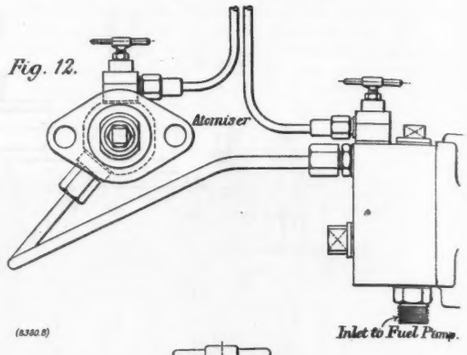
Air for fuel injection is furnished by a three-stage compressor, with intercoolers, worked directly off the crankshaft. The engine is governed by a spring-loaded shaft governor, direct connected with and controlling the fuel pumps. The camshaft is fitted horizontally and is driven by a vertical intermediate shaft and worms, off the crankshaft.

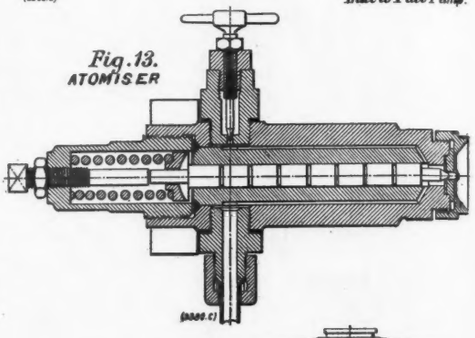
The application of the Diesel engine to marine propulsion to which we have already referred, represents one of the most important spheres of

THE BRITISH EMPIRE EXHIBITION; OIL AND GAS ENGINES.

CONSTRUCTED BY THE NATIONAL GAS ENGINE COMPANY, LIMITED, ENGINEERS, ASHTON-UNDER-LYNE.







FIGS. 11 TO 14. 30-B.H.P. HORIZONTAL TYPE CRUDE OIL ENGINE.

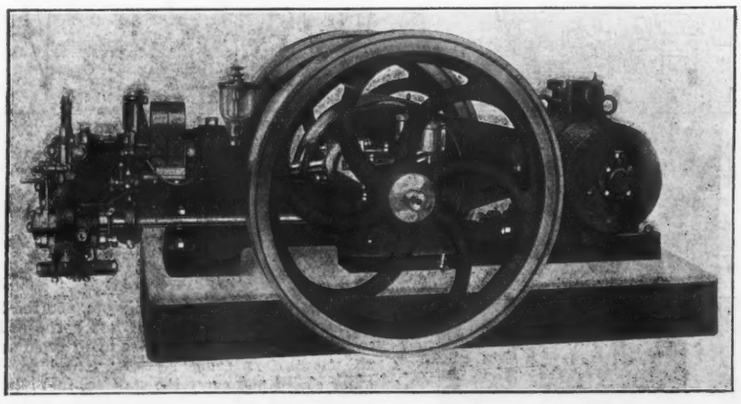
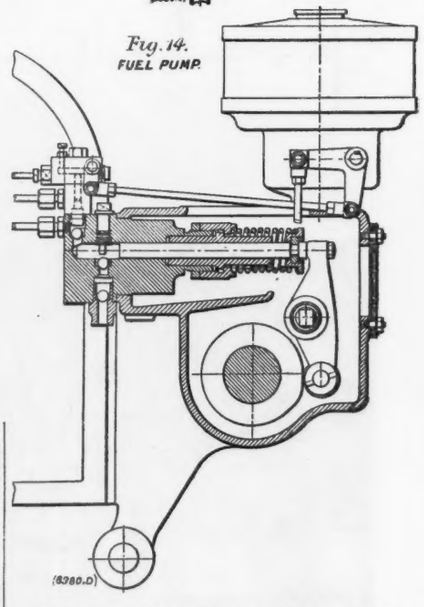


FIG. 15. SMALL PETROL OR PARAFFIN ELECTRIC LIGHTING SET.



advance of the internal combustion engine, and although space considerations make impossible the exhibition of complete power units at Wembley, makers have resorted to the display of models with which to demonstrate their designs. The North Eastern Marine Engineering Company, Limited, of Wallsend-on-Tyne, for instance, have constructed a working model to a scale of an inch to a foot, of their latest type of 3,000 horse-power engine. The details of this design of four-stroke cycle, single-acting marine engine have already been described in our columns, in connection with the installation aboard the Motor Ship Sevilla (see ENGINEERING, vol. cxiii, page 12).

An illustration of the valve gear, as viewed from above the engine, is given in Fig. 7, page 530. For each cylinder there are four main valves, air inlet, exhaust, a needle type for fuel injection and a starting valve. Each valve is placed in a cage. Ease of removal for cleaning is thus obtained. The exhaust valve has a water jacket arranged around it. As the springs are located on the outside, they are well removed from all high temperatures and are also open to view. A single camshaft is used, and on it both the ahead and astern cams are mounted. These are beside one another. The operating levers are mounted on a weighshaft, each on an eccentric fulcrum. As the axes of the eccentrics and the weighshaft are not parrallel, a half revolution of the weighshaft, which is the movement involved in reversing the engine, moves the cam rollers from the ahead to the astern cams. The fuel valve operating system has only one cam and when the reversing gear is operated, the roller is moved to a different position in the same plane. Motion is taken from the crankshaft at the centre of the engine through spur gearing to rotate the half-speed shaft and from this is conveyed to the camshaft by means of long connecting rods coupling small cranks. The whole gear is of a very simple and serviceable nature and thoroughly reliable. Each cylinder has a relief valve, and this is opened whenever the engine is reversed or stopped. It also serves the purpose of a safety valve.

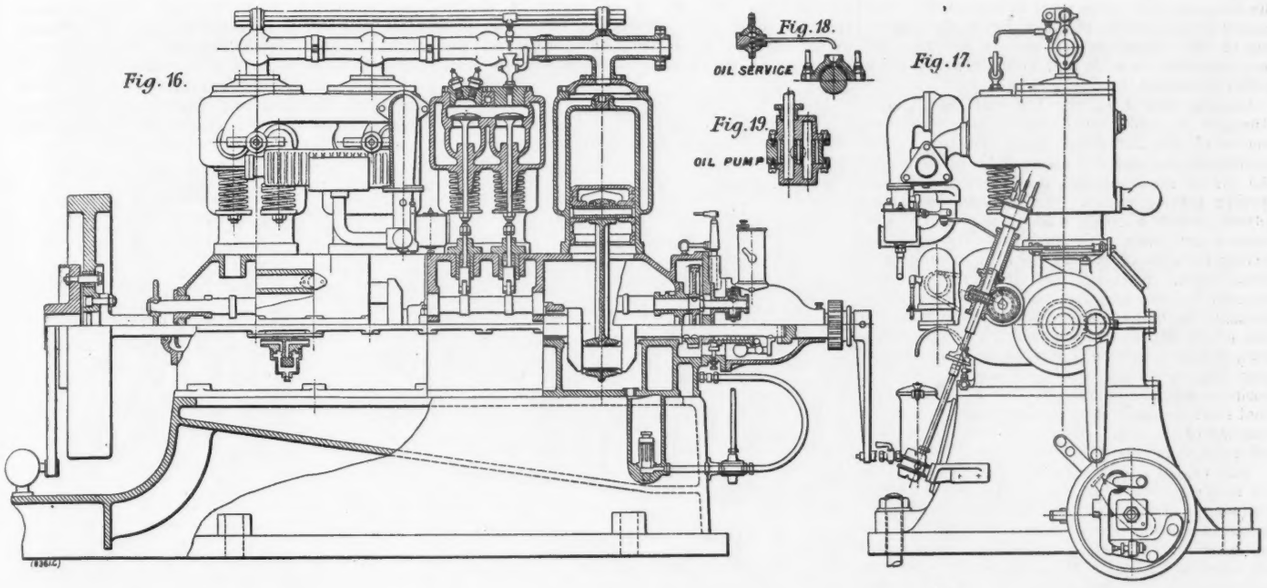
A representative display of many types of internal-combustion engines is made by The National Gas Engine Company, Limited, of Ashton-under-Lyne. The limited space available for exhibition purposes makes it impossible to show their largest plants, of 2,000 brake horse-power, but the firm has been able to demonstrate the qualities of their design and workmanship by means of the smaller sized units. The largest example shown is a three-cylinder vertical type of gas engine, capable of developing 150 brake horse-power as a constant working load. This is directly coupled to an electric generator made by the English Electric Company, Limited. Drawings of the engine are shown in Figs. 8 and 9, page 531, while in Fig. 10 the complete power set is illustrated.

This engine, which works on the four-stroke cycle, has the whole of its reciprocating parts totally enclosed, lubrication being effected by a pump supplying oil under pressure through the crankshaft to the bearings. Control of the speed is arranged by the use of centrifugal governors operating throttle valves. These are provided for both gas and air, and the system is that known as quantity governing. It is possible, however, when required, to combine this method with that in which the mixture is changed with variations of load and thus obtain a combination of quantity and quality governing. Water circulation is adopted for cooling the cylinders and covers, but not for the pistons. A compressed air method of starting is used, in which the air is admitted to the cylinders by means of timing valves operated from the crankshaft and inlet valves of the back-pressure type in the cylinders.

Each cylinder consists of an outer casing, into

BRITISH EMPIRE EXHIBITION; FOUR-CYLINDER PETROL OR PARAFFIN ENGINES

CONSTRUCTED BY THE NEW PELAPONE ENGINE COMPANY, LIMITED, ENGINEERS, DEWSBURY.



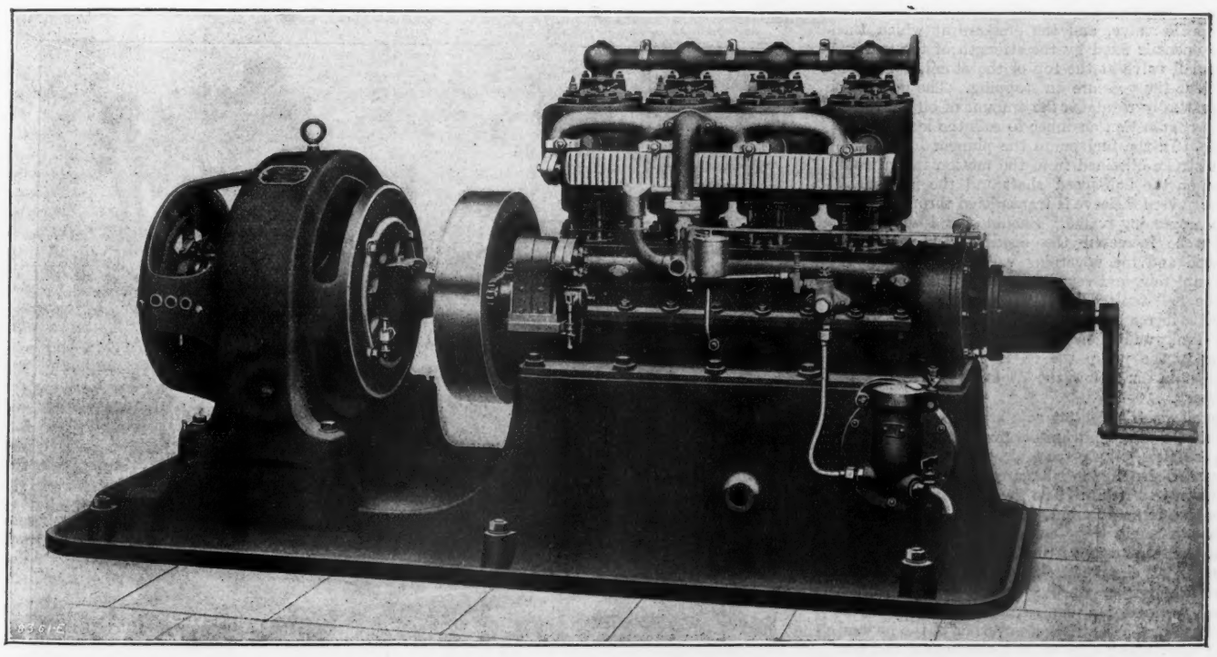


FIG. 20. 20 B.H.P. ELECTRIC LIGHTING SET.

which a loose liner is fitted. This is held down against a joint ring at the top, by means of the cover, but is quite free to expand towards the bottom end. In the cylinder covers the cages for the inlet and exhaust valves are fitted and a water jacket is provided for that of the exhaust valve. The complete cylinder covers can be easily lifted for the inspection of the pistons without dismantling the manifold pipes. The valves are provided with springs of the compression type, the initial compression being given by the tightening up of nuts on the screwed end of the valve spindles. Motion for operating the valves is taken from a camshaft, driven by spur gearing from the crankshaft, and carried through push rods to the valve levers. It will be seen from the arrangement of the inlet pipe in Fig. 9, that the air and gas are kept separate until they actually enter the inlet valve cage, and that the governor motion operates the two throttle valves together. A speeder gear is fitted to the governor in order that the speed of running may be increased or decreased, and actually this is possible to an extent of 5 per cent. on each side of the normal value, while the engine is running. Fig. 9 and that part of Fig. 10 which shows the cylinder in section, provide a clear indication of the construction of the pistons. Marine type connecting rods are provided, of which the bearings are of the flat backed type, held in position by through bolts and a steel cap. A liner is inserted between the two halves of the brasses so as to permit of easy adjustment for wear. Whenever necessary the compression in the cylinders can be adjusted by means of plates between the brasses and the foot of the rod. Phosphor bronze bushes are fitted at the top end of the connecting rod, while the large ends are lined with white metal. The bedplate is cast in a single piece in which the crankshaft bearings are provided with steps. These bearings are round backed, and thus can be removed while the crankshaft remains in place. The complete crankshaft which is machined out of a solid forging, has holes drilled through it for the conveyance of oil under pressure to the various bearings and up through the connecting rods to the gudgeon pin.

The ignition is in duplicate and the magnetos are driven from the camshaft. Timing may be

adjusted whilst the engine is running, if necessary. All the outlet pipes for cooling water from the cylinders, covers, exhaust valve cages and exhaust pipes flow into an open funnel, where the temperature may be regulated. It will be recognised that the designers have given great consideration to the matter of accessibility of every part of the engine, and in their manufacture it may be said that the standardisation is such that absolute interchangeability is assured.

Another exhibit of the National Gas Engine Company is a 30 brake horse-power crude oil engine of the horizontal type. This is a cold starting engine and was designed for operation on the lowest grade of fuel oil, which has a high specific gravity and a calorific value of about 18,000 British thermal units per pound. These engines are made with single or twin cylinders, having a range of powers from 18 to 166 brake horse-power. Working with the fuel already referred to, consumptions run from 0·4 to 0·48 pounds per brake horse-power, according to the size of the engine. Economical working is, therefore, provided, and the illustrations in Figs. 11 to 14, page 532, which show the engine in section, the fuel atomiser and the pump, give evidence of the care that has been taken in the design to ensure that the running of the engine is very simple and that the whole plant is reliable.

This engine is of the solid injection type. The air inlet and the exhaust valves are located in the cylinder head at the top and bottom, (see Fig. 11.) Between them, mounted horizontally, is the atomiser for the fuel, details of the arrangement of which are given in Figs. 12 and 13, while the pump system is shown in section on Fig. 14. The atomiser is of the spring loaded type. The oil is introduced to a small annular space surrounding the needle valve, and the pressure at which the valve opens is fixed by the strength of the spring. The small valve at the top of the atomiser is used to relieve the pressure on stopping. The governor automatically regulates the amount of oil delivered to the combustion chamber to suit the load on the engine. In the fuel pump the plunger has a constant stroke obtained from the motion taken from a cam on the half-speed shaft and the movement of the governor sleeve is transmitted through levers to a governing valve. Should the load on the engine be increased the speed will be slightly reduced and the governing valve closes, partially or completely, and very little or no oil is bye-passed to the fuel tank. When the tendency is for the speed to increase a greater amount is returned to the fuel tank and little enters the engine. Before going to the pump the oil is passed through an exhaust heater below the atomiser to reduce its viscosity.

Small electric lighting sets are also a product of the firm and are procurable for working on town's gas, suction gas, petrol, alcohol or paraffin. A representative engine with a chain-driven dynamo, is shown in Fig. 15. The sizes in which this type of engine is made are 1, 2, 3, 4 and 5½ kilowatts. Although small, these engines have been designed with the same care as the larger powered engines. The salient characteristics of the engine are the small number of working parts, the low engine speed, magneto ignition, satisfactory lubrication to all parts and a centrifugal governor of the hit-and-miss type, which acts to give economical fuel consumptions at all loads. The engine has a loose cylinder liner which can be renewed or re-bored, whenever required. Balance weights are fitted to the crankshaft to improve the steadiness of running. The ignition is effected by a magneto and a variable timing device is provided, the magneto being operated from the side shaft through an eccentric. For the chain drive to the dynamo, a totally enclosed, inverted tooth chain connects the two parts of the plant.

In recent years a great amount of progress has been made in the design of electric lighting sets operated on petrol or paraffin. This has made it possible to obtain satisfactory house lighting in places remote from any company or municipal supply and at small cost. The New Pelapone Engine Company, Limited, of Carr Bridge Works, Dewsbury, has specialised in the provision of this class of plant and that they have produced satisfactory designs for the purpose will be evident from the illustrations on page 533 and below, which show the features of both their large and small sets.

Figs. 16 to 19 show drawings of an engine of 40-45 horse-power, while below it there is a general view, Fig. 20, of an engine of similar type, but of 20 brake horse-power, directly coupled to an electric generator. This latter set was supplied for the lighting of Goldsborough Hall,

Fig. 21.

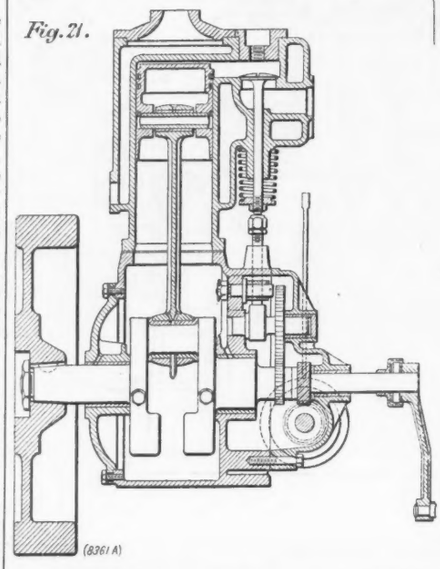
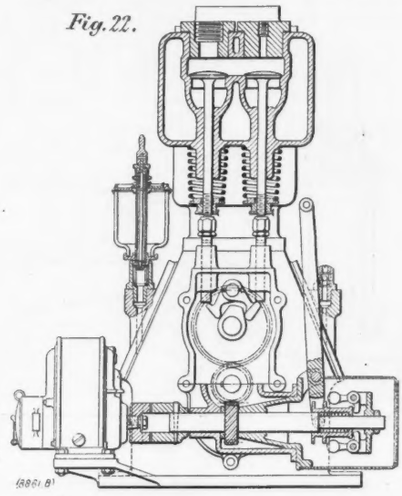
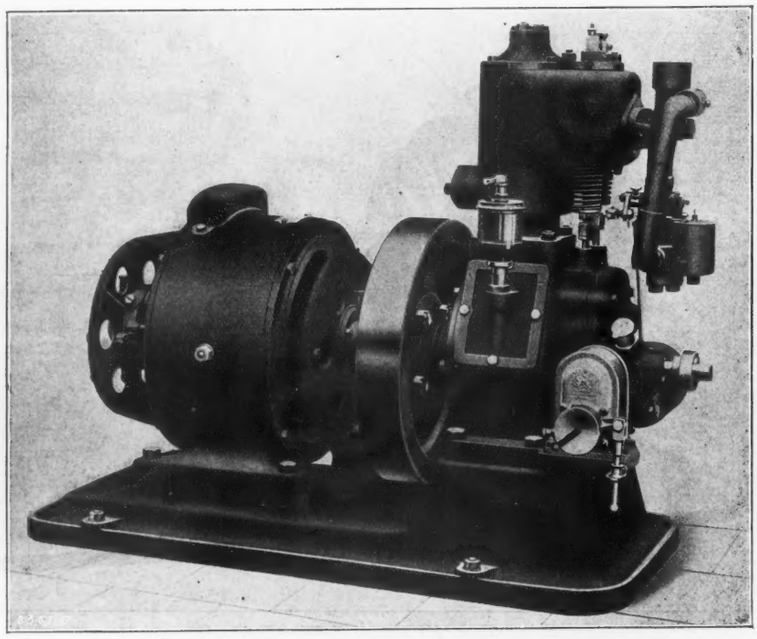


Fig. 22.





FIGS. 21 TO 23. SMALL POWER PETROL OR PARAFFIN ELECTRIC LIGHTING SET; THE NEW PELAPONE ENGINE COMPANY, LIMITED, DEWSBURY.

the Yorkshire residence of Princess Mary. These engines have four cylinders, cast separately and mounted on the top half of the crankcase. The admission and exhaust valves are side by side and mechanically operated from cams cut out of the solid with the camshaft. In the design of the tappets every care was taken to reduce noise in working to a minimum. Each cam roller has its spindle fitted in the wider part of the tappet and is held down to the cam by a helical spring housed in a sleeve casting, bolted to the top of the crankcase. The water jackets encircle the whole of the operative part of the cylinder and are extended to surround the valves and ensure the cooling of the valve spindles. The water outlet is above the head of each cylinder, being arranged on a detachable jacket head. The crankcase is in two parts, the dividing line being at the centre line of the crankshaft. There are bearings for the forged steel crankshaft between each pair of cylinders, as well as at the ends. These are supported in the bottom half of the crankcase while those for the camshaft are part of the casting of the top half. For lubrication a plunger pump is driven by an eccentric on the camshaft and draws oil through a well-designed filter, from a reservoir in the bedplate. This lubricant is sprayed on each main bearing but all the others are provided with oil on the splash system. A centrifugal governor of the ball type runs in an oil bath, and controls the speed of running within fine limits. These engines are supplied to run on petrol or paraffin. In the former case a Zenith carburettor is fitted, while in the latter a vapouriser of Pelapone design is utilised. Many of these engines are supplied for purposes other than electric power generation such as the driving of pumps for sprinkler installations, and, especially the larger size, for operating turbine pumps for fire fighting, a purpose for which they are used in many British aerodromes. When installed to operate pumps for sprinkler systems the engine is started automatically by means of a heavy type of motor-car electric starter. Whenever the pressure in the

THE BRITISH EMPIRE EXHIBITION; L.N.E.R. 4-6-2 THREE-CYLINDER LOCOMOTIVE.

DESIGNED BY MR. H. N. GRESLEY, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

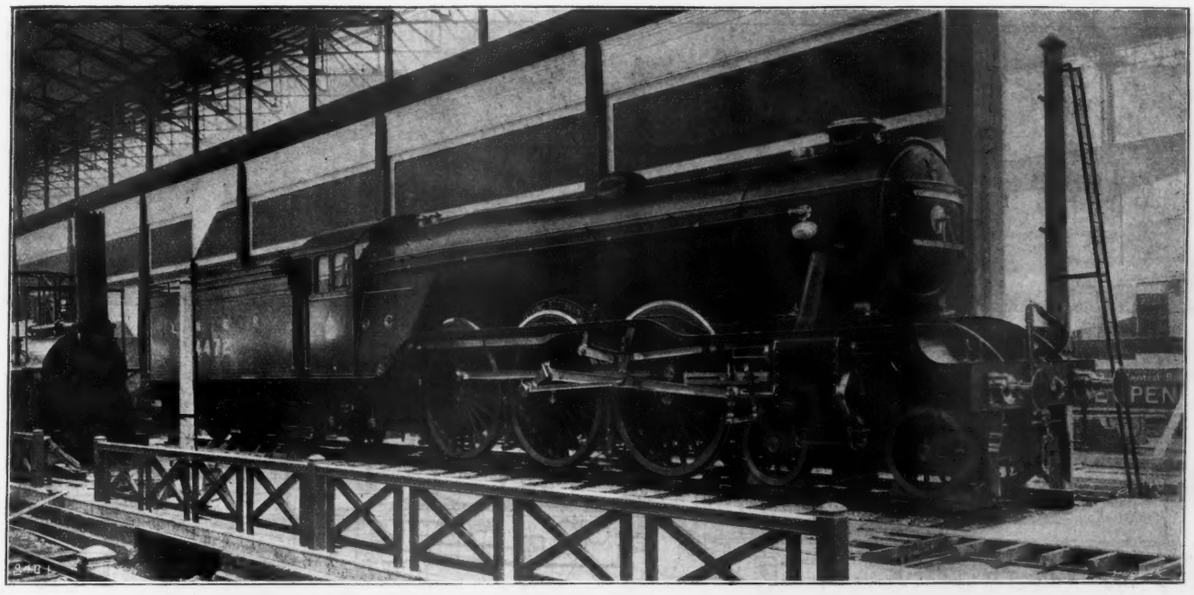


FIG. 1. THE LONDON AND NORTH EASTERN RAILWAY EXHIBIT IN THE PALACE OF ENGINEEERING.

sprinkler pipe system falls the engine commences to operate and keeps the pipe system filled with water and maintains the pressure.

When only a small amount of power is requisite the smaller class of engine, shown in Figs. 21 to 23, opposite, may prove suitable. This type of plant is made in 1 and 2 horse-power sizes and it also works on the four-stroke cycle. Figs. 21 and 22 give details of the design of the engine, while Fig. 23 shows the general appearance of a complete lighting set. In this engine a single cam is provided to operate both valves and the motion is carried through to the adjustable tappets by means of two small radius arms, swinging from a centre above the small camshaft. On the crankshaft, which is again a drop forging of high tensile steel, there are balance weights provided which are forged with the shaft itself. Beside the timing wheels a drive is taken by a worm wheel to the governor shaft (see Fig. 22.) The governor is of the centrifugal ball type and motion is taken from its sleeve by a lever to change the position of the throttle valve. From the other end of the governor shaft the drive for the magneto is obtained through a dog clutch. Lubrication is arranged for on the splash principle, a sight feed lubricator being provided for make up.

RAILWAY MATERIAL—I.

The railway exhibits are perhaps not quite so extensive as might have been expected in view of the importance of this branch of industry, the part it has played in the expansion and development of the Empire, and the standing which our locomotive building firms and manufacturers of other railway material and plant hold in the world's markets. The examples of British work shown, however, are all typical and of interest, some of them being very fine specimens indeed, of British design and workmanship. The more imposing exhibits include the locomotives of the London & North Eastern Railway and the London Midland & Scottish and Great Western Railways, while interesting samples of coaching stock are shown by the London Midland & Scottish, the Metropolitan Railway and the Metropolitan Carriage, Wagon and Finance Company, Limited.

The most striking exhibit of all is, probably, that of the London & North Eastern Railway. We refer to this at length below. The London Midland & Scottish Railway locomotive is of the "Prince of Wales" type, which was illustrated and described in ENGINEERING of May 11, 1923. It is a 4-6-0 type of engine with inside cylinders and Walschaert valve gear. The engine exhibited is one actually constructed by Messrs. William Beardmore and Co., Limited, and it is shown at that firm's stand. At the stand of the North British Locomotive Company, Limited, Glasgow, a large geared turbine locomotive is shown. This has been designed on the Reid-MacLeod system and we shall hope to refer more adequately to this engine, which presents the greatest departure from normal practice to be seen at the exhibition, on a future occasion. The machine is fitted with two-stage turbines, condensing plant, and forced draught. The most prominent feature of the London Midland & Scottish Railway's own stand is an example of the company's latest type of third-class vestibule coach. This vehicle contains two third compartments, together accommodating 57 passengers, and has two lavatories. The length over body is 57 ft. and the weight 27 tons. Two 4-wheel bogies of 9-ft. wheel base, are employed, centred 40 ft. 6 in. apart. The Metropolitan Railway shows an interesting vehicle in the form of a first-class control trailer coach for electric working, but the most sumptuous example of the railway coach-builder's art is the State saloon constructed for H.M. the King of Egypt, exhibited by the builders, the Metropolitan Carriage, Wagon & Finance Company, Limited. At a later date, we hope to deal with these and other exhibits in the railway section. For the moment, owing to exigencies of space, we must devote ourselves to two items only, viz., the locomotives of the London & North Eastern Railway, and the exhibit of the Metropolitan Carriage, Wagon and Finance Company, Limited.

The exhibit of the London and North-Eastern Railway, Fig. 1, is of historic as well as present interests as it contrasts the locomotive of a hundred years ago with the modern unit required to handle the heavy expresses of the London to Leeds service and the East Coast route. Next year will be the centenary of British railways. Locomotive building was of earlier date, since before they were used for railway working locomotives had been employed on colliery lines and sidings. In 1825, however, the first railway, as such, was opened. The line was intended for coal traffic and goods, but on the opening day numbers of people travelled by the train which made the first trip, and the experience led to a demand that passengers should be conveyed as well as goods and coal. Thus, quite unintentionally, the Stockton and Darlington line became the first railway to start the development of this form of transport in Great Britain, and the country had the honour of being the pioneer of the world as regards a system of communication which has led to greater changes on the face of the earth than any other invention of man. To George Stephenson we owe the success of the Stockton line. The credit for this is often given to Edward Pease, to whose enterprise, determination, and business ability the undertaking was undoubtedly due. But it must be remembered that the line as originally decided upon was relatively badly aligned and that steam power had not been even contemplated when Pease set it afoot. It was not till George Stephenson took charge as the company's engineer that the alignment was improved, and it was wholly due to Stephenson's faith in steam traction that powers were obtained to employ locomotives, and that a trial was given to this form of haulage. Stephenson's faith was justified, and the first locomotive to be used on a public railway performed, for those days, extremely creditably. After a strenuous life this engine has, fortunately, been preserved for us, and as a relic of national value fittingly finds place in the exhibition of the British Empire, which railways have done so much to develop. The old engine, Locomotion, No. 1, which we illustrate in Figs. 6 and 7, Plate XL, is not quite as it was originally built. The changes introduced, however, do not mar its value as an early presentation of locomotive design and construction. The cylindrical boiler, of $\frac{3}{8}$-in. plates, was 4 ft. in diameter, and the internal flue 22 in. in diameter. The two cylinders were 10 in. in diameter with a stroke of 24 in. The cylinders were placed vertically over the axles, and the greater part of each, together with the steam chest, was inside the steam space. The piston rods were provided with cross-bars which were constrained to move each in a vertical plane by means of parallel motions. Reversing was accomplished by means of a loose eccentric, the valve gear being disconnected, the valves

THE BRITISH EMPIRE EXHIBITION; L.N.E.R. 4-6-2 THREE-CYLINDER LOCOMOTIVE.

DESIGNED BY MR. H. N. GRESLEY, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

(*For Description, see Page 537.*)

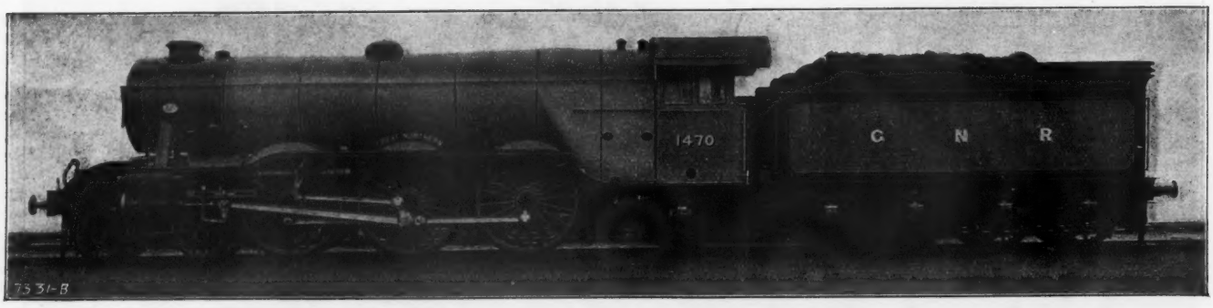


FIG. 2.

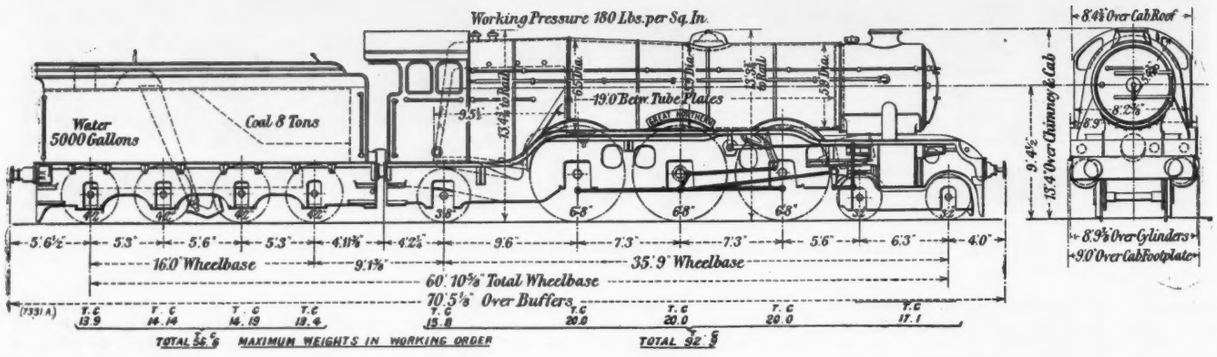
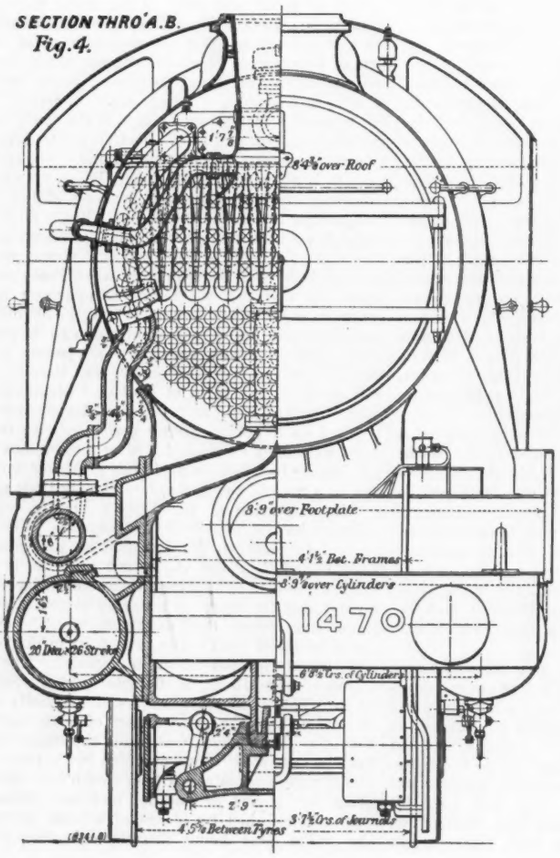
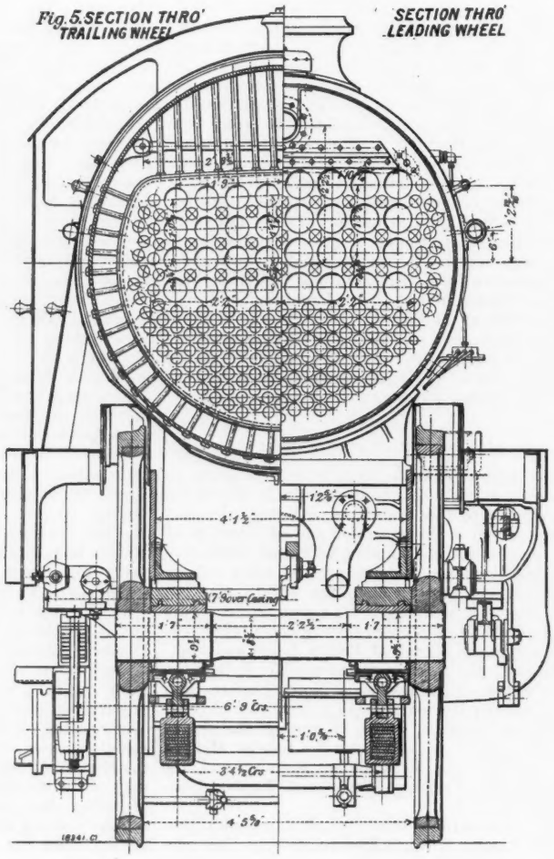


FIG. 3.





BRITISH EMPIRE EXHIBITION; LOCOMOTIVES OF THE LONDON AND NORTH EASTERN RAILWAY.

(*For Description, see Page 535.*)

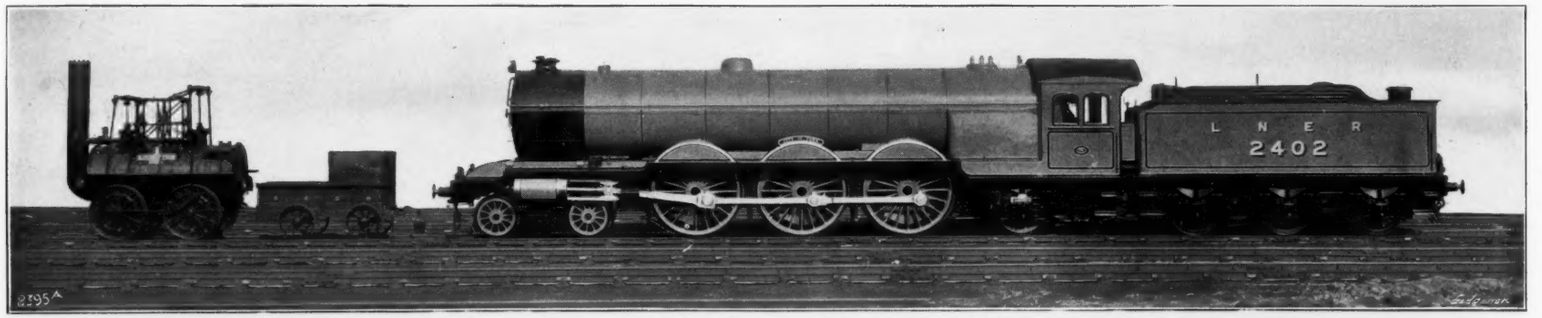


Fig. 6. "Locomotion No. 1," Built in 1825; "City of York" of the Pacific Type, Built in 1924.

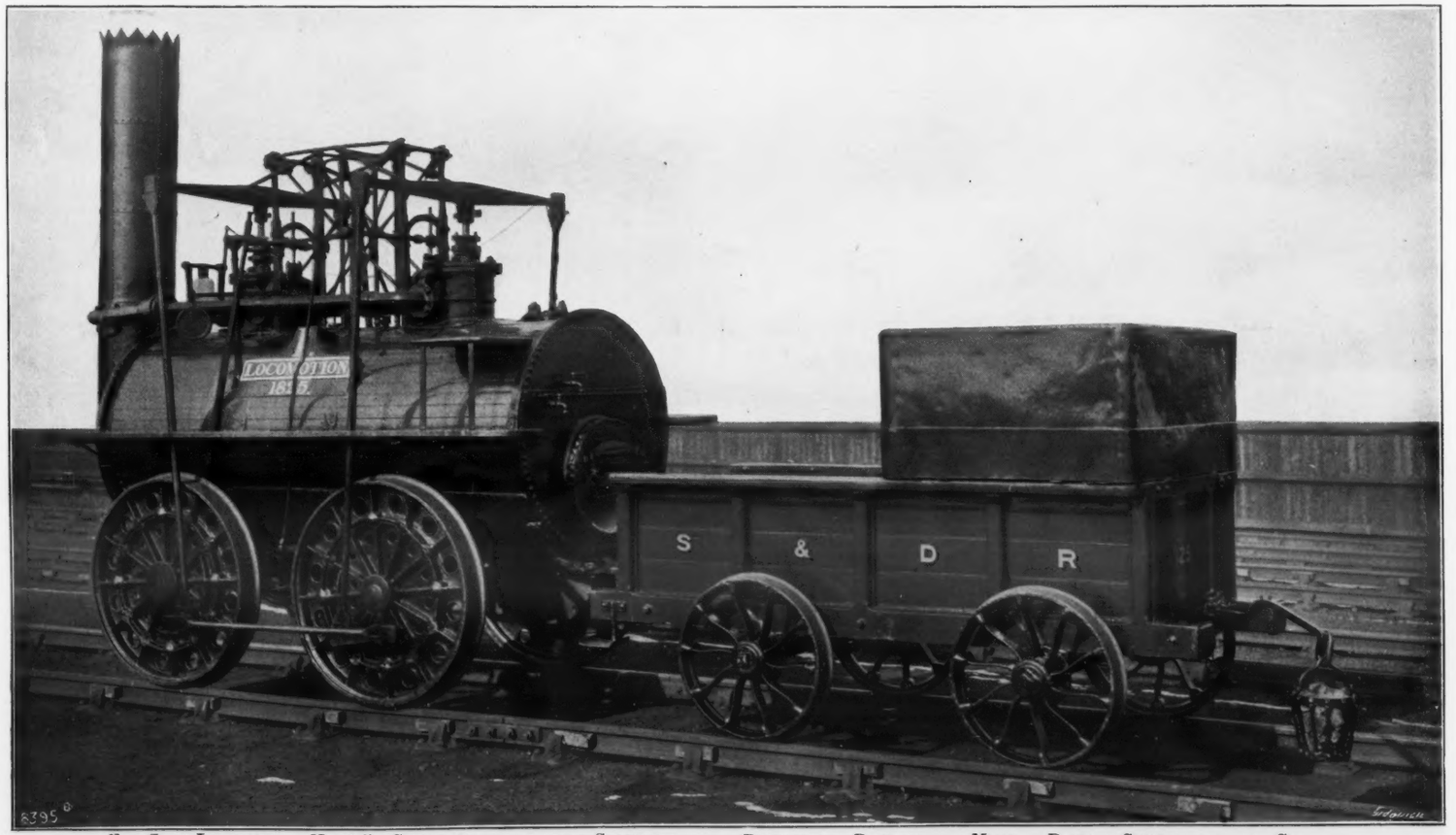


Fig. 7. "Locomotion, No. 1." Constructed for the Stockton and Darlington Railway by Messrs. Robert Stephenson and Co.

(*To face page 536.*)

THE BRITISH EMPIRE EXHIBITION; L.N.E.R. 4-

DESIGNED BY MR. H. N. GRESLEY, M.INST.C.E.,

(For Description see Page 5

Fig. 8

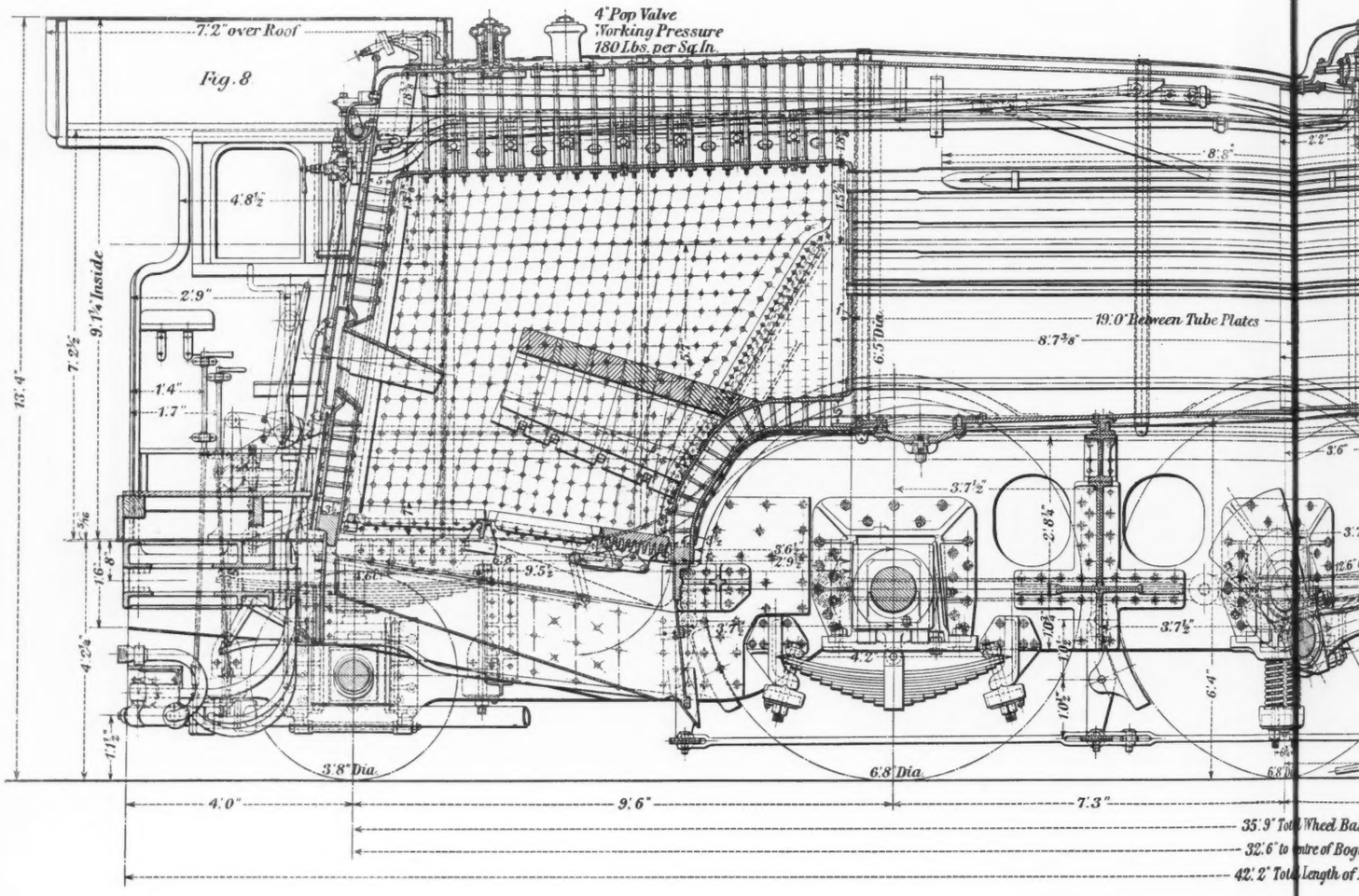
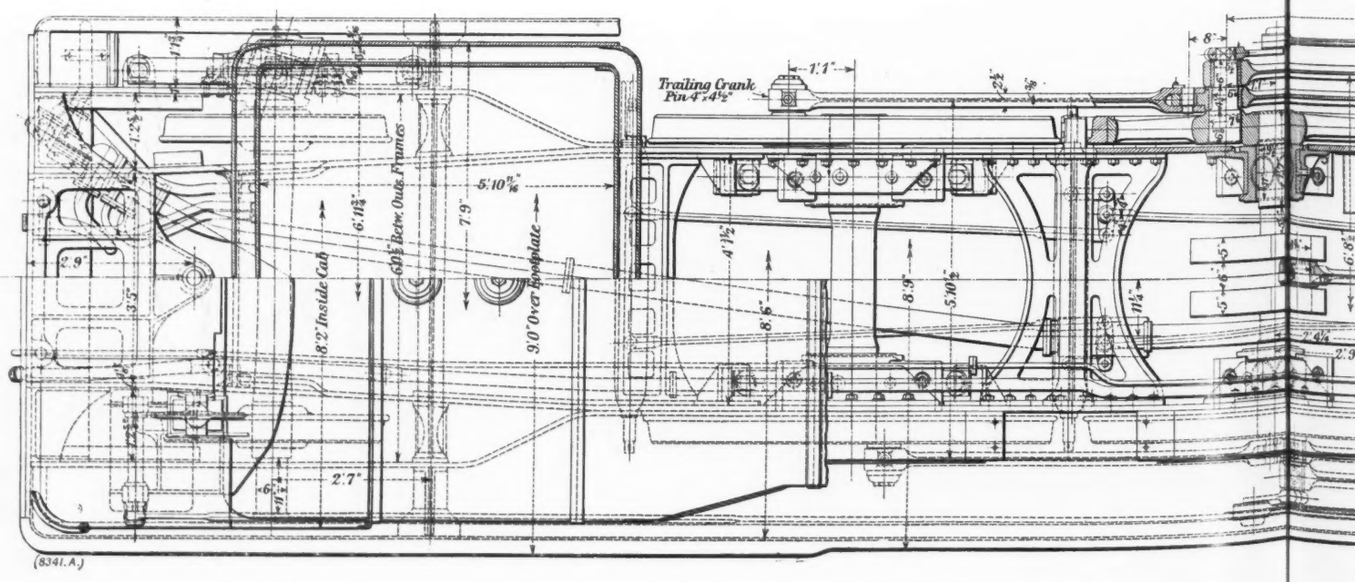


Fig. 9

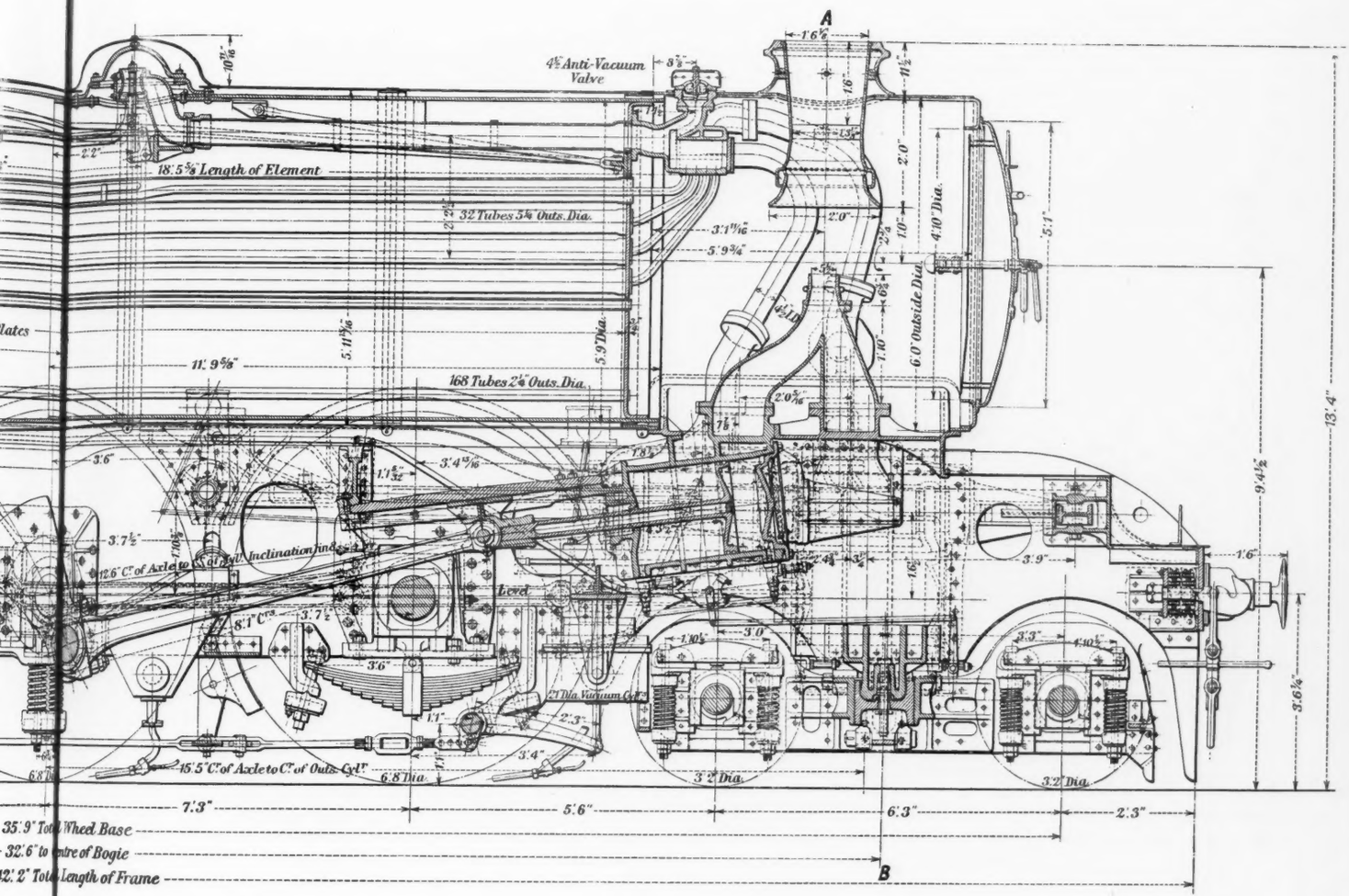


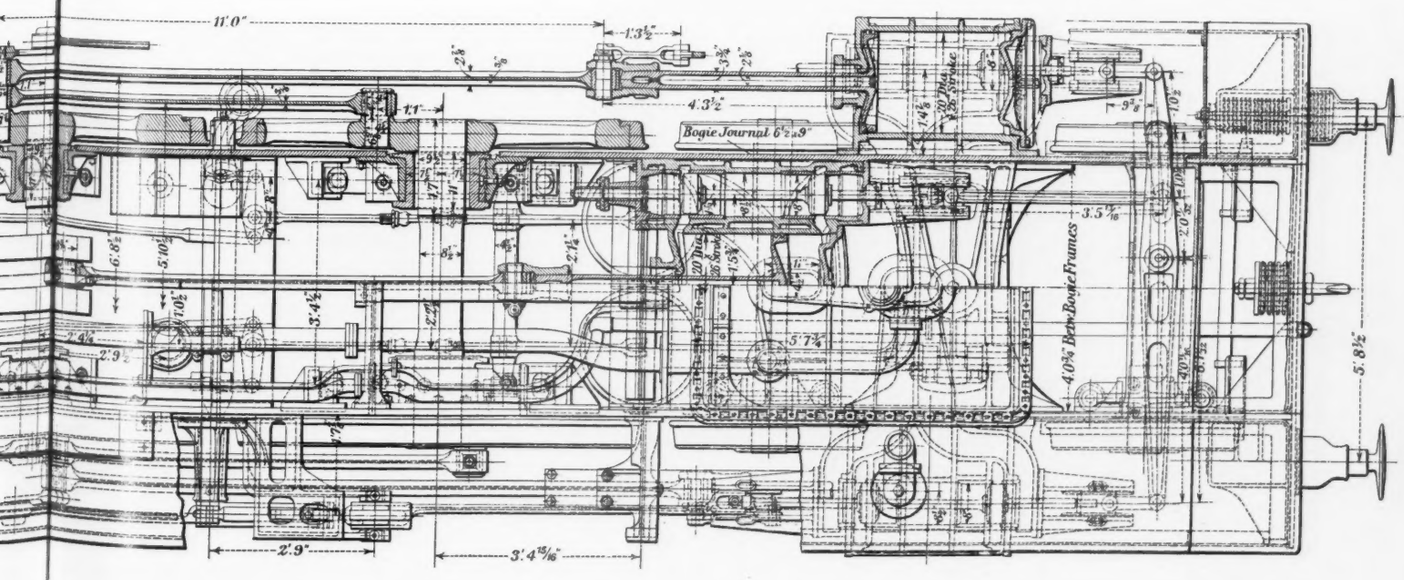
(8341.A.)

; L.N.E.R. 4-6-2 THREE CYLINDER LOCOMOTIVE.

RESLEY, M.ST.C.E., CHIEF MECHANICAL ENGINEER.

For Description, see Page 535.)





THE BRITISH EMPIRE EXHIBITION: L.N.E.R. 4-6-2 THREE-CYLINDER LOCOMOTIVE.

DESIGNED BY MR. H. N. GRESLEY, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

(For Description, see Page 535.)

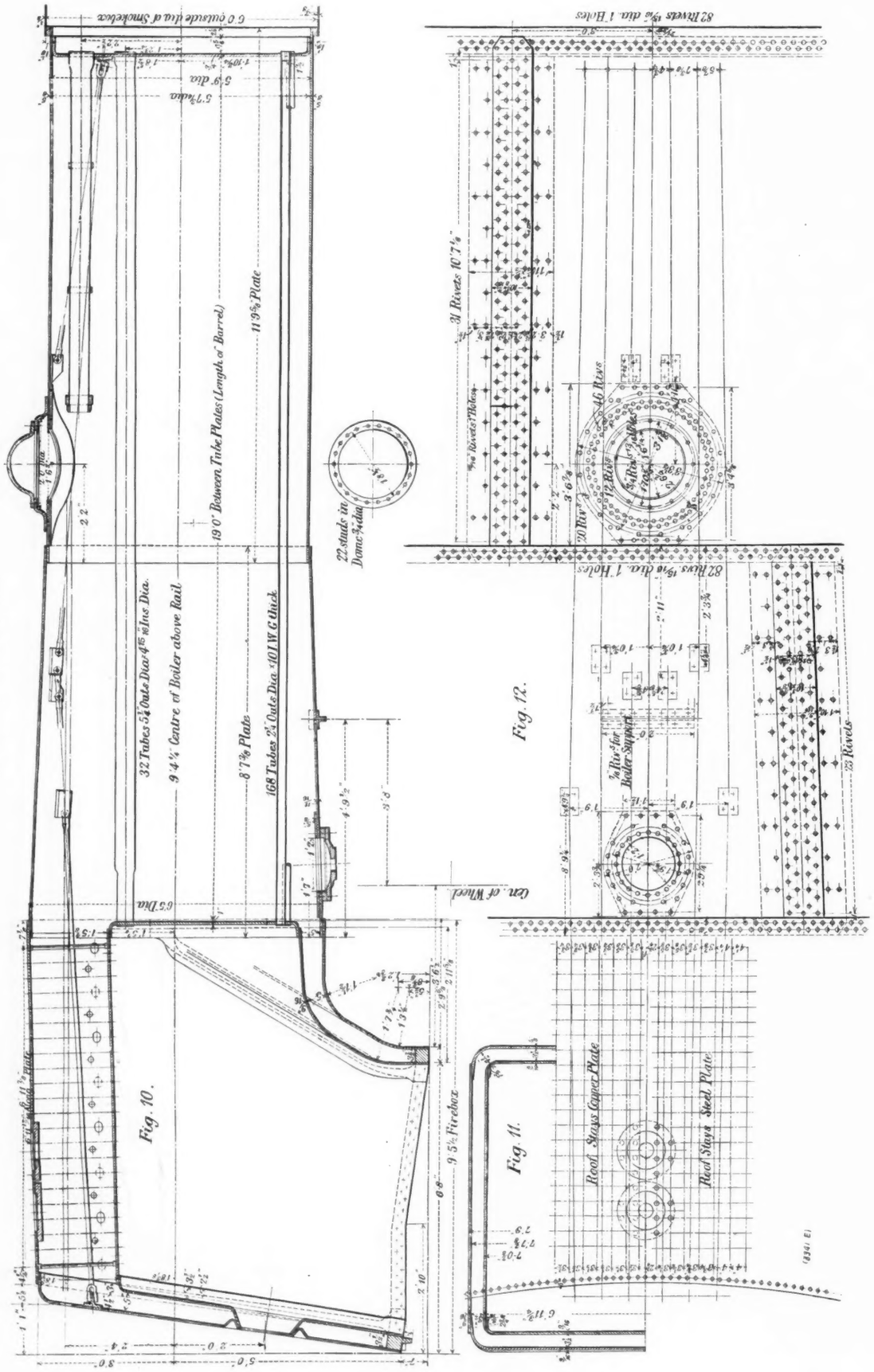


Fig. 10.
Fig. 11.
Fig. 12.
32 Tubes 5¼ Outs. Dia. 4⅝ Ins. Dia.
168 Tubes 2¼ Outs. Dia. 10 W.G. Thick.
9' 4½" Centre of Boiler above Rail
19' 0" Between Tube Plates (Length of Barrel)
8' 7⅜ Plate
11' 9⅝ Plate
22 studs in Dome ¾ dia.
82 Rivets ⅝ dia. 1 Holes
31 Rivets 10' 7⅛"
46 Rivets
12 Rivets
20 Rivets
3 Rivets
3 Rivets
Roof Stays Copper Plate
Roof Stays Steel Plate
9' 5⅝ Firebox
Ctrs. of Wheels

(To face page 537.)

THE BRITISH EMPIRE EXHIBITION; L.N.E.R. 4-6-2 THREE-CYLINDER LOCOMOTIVE.

DESIGNED BY MR. H. N. GRESLEY, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

Fig. 13.

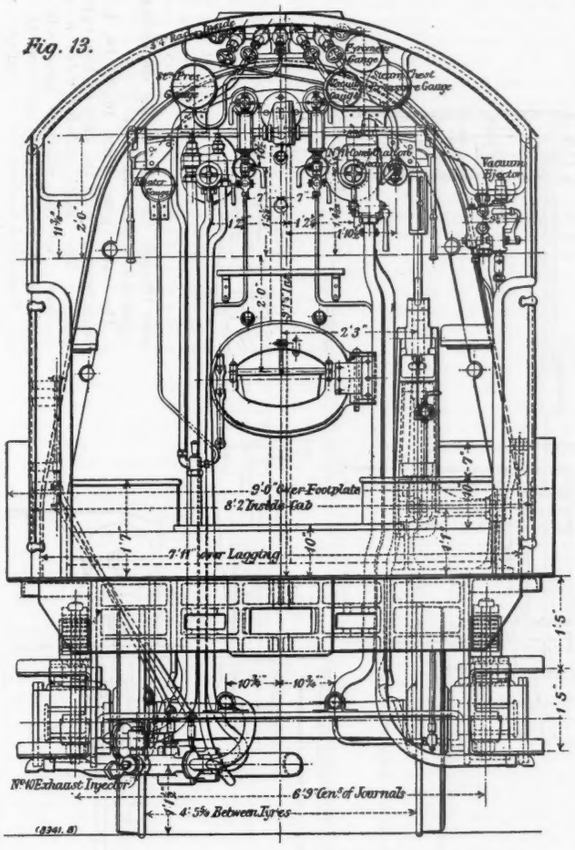


Fig. 14.

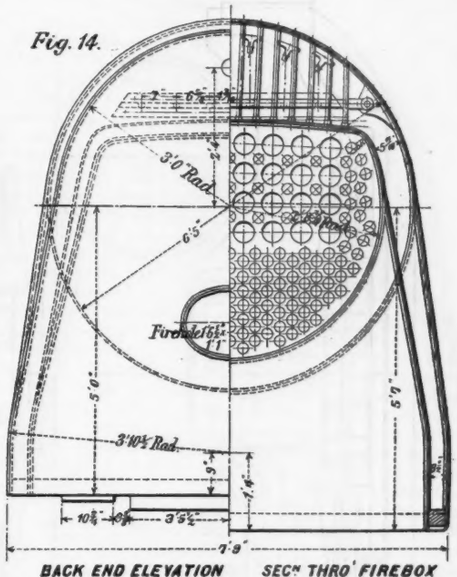
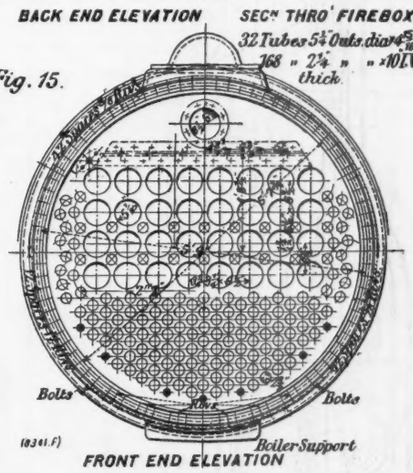


Fig. 15.



reversed by hand, and the gear recoupled again. At Wembley this engine is driven by an electric motor so that the valve motion will be seen at work. Steam pressure from 25 lb. to 50 lb. was carried. The boiler was fed by pump and the exhaust was carried into the chimney by means of a breeches pipe. A bell was provided, whistles not having then been introduced. A fire devil was hung from the tender buffer beam. The regulator handle was connected to a regulator rod passing through a stuffing box into the boiler. The rod was fitted with a double crank coupled to a flat valve working across the base of the steam chest.

On the opening day of the railway this engine hauled a load of about 90 tons, at one part of the trip attaining a speed of 15 m.p.h. The contract price was 500*l.*, which was also the figure paid for a second engine delivered to the railway by Messrs. Robert Stephenson some two months or so after the opening. The contrast between this early machine, whose promise was so problematical that horse traction was concurrently employed on the Darlington line, and the product of modern design shown alongside it in Fig. 6 is striking indeed. The "City of York" shown in that view is one of the class of 4-6-2 engines built recently at Darlington. The engine at Wembley is one of the sister class built at Doncaster to Mr. H. N. Gresley's design. It is well shown in Fig. 1. The one hundred years which have elapsed have made imperative machines capable of handling over 600 tons at an average speed of over 50 m.p.h. and maximum speed of over 70 m.p.h. To meet these requirements Mr. Gresley introduced in 1922, on the then Great Northern, engines which constituted a considerable advance on previous British practice. When the first of these engines was put into service they were illustrated and described in our columns (see vol. cxiii, page 454). Fig. 2, page 536 shows the first engine of the class. We are now able to give on Plates XL to XLII, and pages 536 to 538 drawings of this class of engine, of which 12 had been built by the end of 1923, while 40 more are to be completed this year.

"Locomotion" No. 1 of the Stockton and Darlington weighed about 6½ tons. No. 4472 of the L. and N.E. 4-6-2 class weighs, with tender, 148 tons 15 cwt. The latter has three cylinders, and a boiler whose largest diameter is 77 in. and possesses many unusual features. The chief of these is the form of the fire-box, which is fitted with a combustion chamber after the manner of engines on the Pennsylvania R.R., while the superheater elements are provided with much shorter return bends than is common practice. The diagram, Fig. 3, page 536, shows the principal dimensions, &c. A longitudinal section is given in Fig. 8, Plate XLI, Fig. 9 showing two half-plans. End elevations and various cross-sections are shown in Figs. 4 and 5, page 536 and 13, above, while Figs. 10 to 12, Plate XLII, and 14 and 15, above, are drawings of the boiler; Figs. 16 to 18, page 538, relating to the valve gear. For detail particulars and dimensions we would refer our readers to the table on page 539; we propose to give here some general notes on the engine.

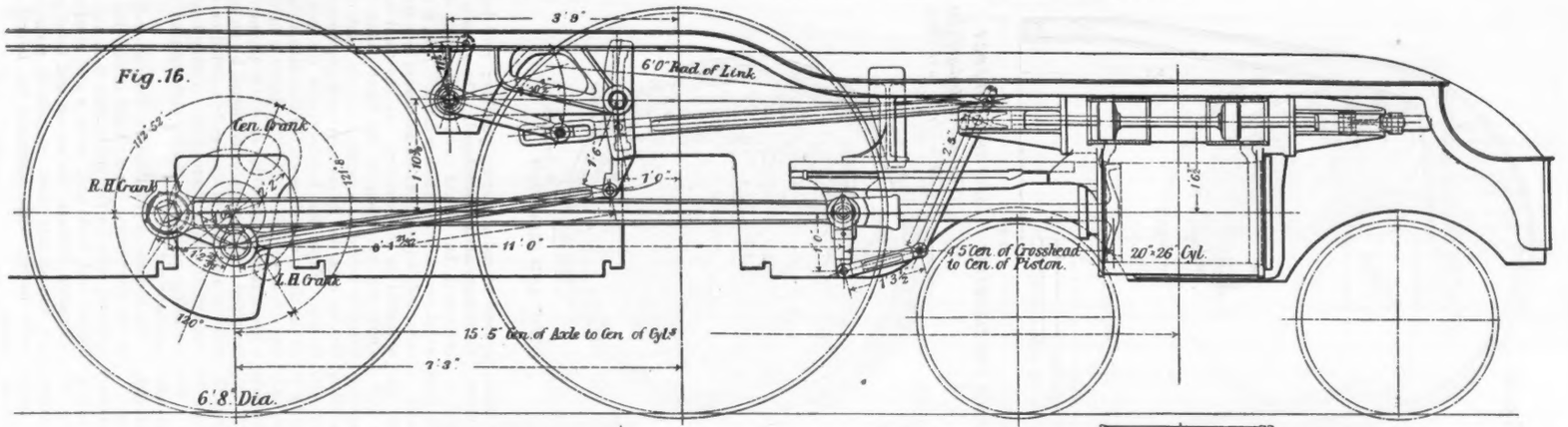
The boiler barrel has one parallel course connected with the fire-box shell by means of a taper course, the under side of which is horizontal, Fig. 10. The dome is situated on the parallel course. The longitudinal joints (Fig. 12) are butt joints with double butt straps, and are quadruple-riveted. The fire-box is of the wide form (Fig. 14) first adopted in this country in Mr. Ivatt's Atlantics, but, as above noted, fitted with a combustion chamber (Fig. 10.) The latter makes a more perfect system of radial staying possible; roof bars and palm stays are not employed. The grate is partly horizontal, but sloped towards the front end, at which part a drop section is fitted. This, it may be remarked, is a device which has always been strangely neglected in this country. At the front end the smoke-box extension of the front course of the barrel is bolted to a saddle. At the back end the fire-box is carried by castings extending between the frames. Expansion brackets hold the box down at the sides, and shoes on the foundation ring give support at the back end. The boiler is fitted with a steam turret from which several of the mountings are piped. The regulator is worked by an inverted lever on each side of the fire-box, fitted on a cross shaft which passes through two stuffing-boxes in a mounting enclosing a short arm coupled to the regulator rod.

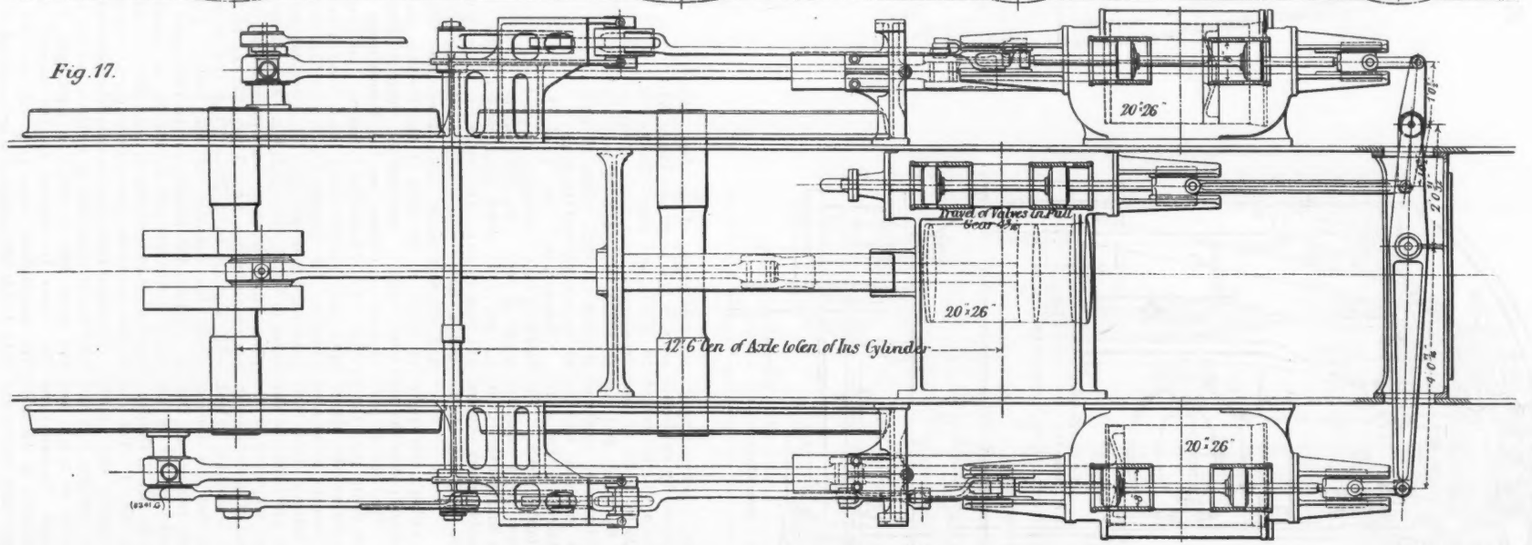
The frames are 1⅛ in. thick. They are well stayed at the front buffer beam, bogie centre, the inside cylinder, yoke for the inside slide bars, and at the firebox and back end, while a stiff steel casting is situated between the second and third coupled axle and at this point support is given to the boiler barrel, with allowance for lateral movement.

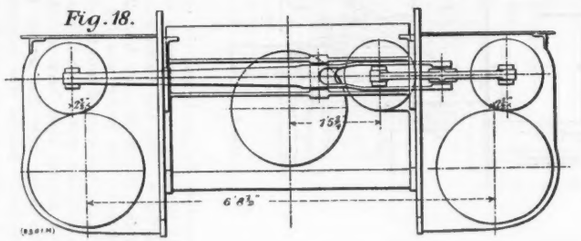
The cylinders, as previously stated, are three in number, all driving on to the middle coupled axle. The two outside cylinders are horizontal and on the driving-axle centre line. The inside cylinder is

THE BRITISH EMPIRE EXHIBITION; THREE-CYLINDER VALVE GEAR OF L.N.E.R. LOCOMOTIVE.

DESIGNED BY MR. H. N. GRESLEY, M.INST.C.E., CHIEF MECHANICAL ENGINEER.







further to the rear and is inclined at 1 in 8, so that the rod may clear the first coupled axle. The exhaust passages for the outside cylinders communicate with the blast pipe by way of the saddle. Those for the inside cylinder are complete in the casting. The blast pipe combines all by means of a branch connection to the inside cylinder casting. The valves are all horizontal and in the same plane. Each cylinder has a separate steam pipe from the superheater header. Those for the outside cylinders pass through the sides of the smoke-box to the upper side of the steam chest.

The valve gear, Figs. 16 to 18, is of the Walschaert type in the case of the outside cylinders. The inside cylinder valve is operated indirectly on the principle previously adopted by Mr. Gresley. This arrangement involves two horizontal rocking levers connected with the outside cylinder-valve tail rods. These levers are of unequal length. The longer has two

unequal arms respectively 4 ft. $\frac{11}{16}$ in. and 2 ft. $1\frac{1}{32}$ in. long between centres; the shorter has two equal arms 1 ft. $\frac{1}{2}$ in. long. Each lever is coupled at one end to its valve spindle by a short link. The long lever is pivoted on a fixed point; the short one is pivoted on the short arm of the long. The second end of the short lever drives the valve spindle of the inside cylinder by means of a long link. Roller bearings are fitted to the large lever at the fulcrum-pin and pivot-pin of the short lever. The arrangement will be clear from Figs. 17 and 18, which show details of the gear.

The pistons and rods are forged in one piece of nickel-chrome steel and the piston rod is bored out to reduce the weight of the reciprocating parts. The pistons have a bronze ring cast round the head to reduce wear. Two snap rings are used. The return cranks of the Walschaert gear are fitted with ball bearings. Reversing is by screw, the gear being fitted with ball bearings and with a power lock operated by the vacuum maintained for the brake. Simultaneously a Ferodo-lined clutch worked by the vacuum comes into action on the weigh-bar shaft.

The connecting and coupling rods are of nickel-chrome steel heat-treated with an ultimate tensile strength of 50 tons per square inch and yield-point 80 per cent. of the tensile strength. The big-ends of the outside connecting rods are plain bushed eyes. The inside-rod big-end has a semi-circular cap held to the T-end of the rod by two bolts solid with the cap. Among the smaller details, it may be mentioned that the cylinder cocks are operated by Bowden wire.

The following table gives the principal dimensions and other particulars of this class of London and North Eastern Railway locomotive :—

Locomotive	
Cylinders (three)	20 in. by 26 in.
Valves, piston	8 in. diam.
,, maximum travel ...	$4\frac{9}{16}$ in.
,, steam lap	$1\frac{1}{4}$ in.
,, exhaust lap, negative...	$\frac{1}{4}$ in.
Return crank radius	$6\frac{3}{4}$ in.
Cut-off, full gear	65 per cent.
Wheels diameter, bogie ...	38 in.
,, ,, coupled ...	80 in.
,, ,, trailing ...	44 in.
Journals, coupled wheels ...	$9\frac{1}{2}$ in. by 11 in.
Boiler barrel, maximum diam....	77 in.
,, ,, minimum ,, ...	69 in.
,, ,, length	19 ft.
Fire-box shell, total length ...	9 ft. $5\frac{1}{2}$ in.
,, ,, width outside ...	7 ft. 9 in.
,, length inside top ...	7 ft. $11\frac{3}{4}$ in.
,, ,, ,, bottom	5 ft. $10\frac{11}{16}$ in.
,, width inside bottom ...	6 ft. $11\frac{1}{2}$ in.
Tubes, small (168)	$2\frac{1}{4}$ in.
,, large (32)	$5\frac{1}{4}$ in.
,, length	19 ft.
Heating surface tubes	2,715 sq. ft.
,, ,, fire-box ...	215 ,,
(Total)	2,930 ,,
Superheating surface	525 sq. ft.
Grate area	41·25 sq. ft.
Working pressure	180 lb. per sq. in.
Tractive effort at 85 per cent.w.p.	29,835 lb.
Weight on bogie wheels ...	17 tons 1 cwt.
,, ,, coupled wheels ...	60 tons.
,, ,, trailing wheels ...	15 tons 8 cwt.
(Total)	92 tons 9 cwt.
Tender	
Water capacity	5,000 gallons.
Coal ,, ...	8 tons.
Locomotive and Tender	
Weight in working order ...	148 tons 15 cwt.

The most conspicuous and interesting of the exhibits at the stand of the Metropolitan Carriage, Wagon and Finance Co., Limited, of Birmingham, is the new state saloon just completed by the firm for H.M. King Fuad of Egypt, to which we have already referred. This is for the standard gauge State Railways, and has a length over buffers and gangways of 69 ft. $1\frac{1}{4}$ in., the length on end pillars being 65 ft. 9 in. The car runs on two four-wheel bogies of 9-ft. wheel base, centred 45 ft. apart. The width over roof cornice is 9 ft. 11 in., and over pillars 9 ft. 3 in., the height from rail to top of roof being 14 ft. 2 in. The general arrangement of the interior comprises seven sections in all. Commencing at one end of the coach with a vestibule across the whole width, the next section consists of the saloon compartment having an interior length of 14 ft. 5 in., and, of course, extending from side to side of the vehicle. Next to this is a bureau, having a length of 11 ft. $9\frac{3}{8}$ in. interior measurement, the section adjacent to this being the bedroom, with a length of 11 ft. $6\frac{1}{4}$ in. inside. From the end partition wall of this section to the end of the coach a side corridor, 2 ft. $1\frac{1}{2}$ in. in width, is provided, off which open, in order, a bathroom and lavatory next to the bedroom, a valet's compartment, and a compartment for an attendant.

Reserving the general features of construction of the coach, we may first deal with the general characteristics of the exterior and interior. The coach body is painted in cream picked out in gold lines. The lower part of the side is divided into six panels, on the centre dividing line the coat of arms of the King of Egypt being painted by hand. The side lights are nearly all 4 ft. long, and have been carefully placed to give a symmetrical appearance. The interior treatment shows a good deal of variety. The vestibule, which has a length of 5 ft. $7\frac{7}{8}$ in., is painted in neutral grey and has a blue carpet. The fittings are of gunmetal. The saloon opening off this is furnished with a settee, chairs and a side table. The interior finish of this compartment is carved satinwood pilasters with quartered panels of the same wood, the style of decoration being of the Louis XIV period. The metallic fittings are in this instance oxidised silver. The curtains are of dark blue silk; the chairs and couch are covered in blue morocco, the carpet also being blue. A central door leads to the bureau or office, which is in the Adams style. Mahogany panels are inlaid with satinwood bandings. The furniture includes a writing bureau with a 4 ft. by 2 ft. table top, a book-case, and a wardrobe 3 ft. by 1 ft. deep. In this compartment a writing and two easy chairs are provided. The general colouring of this room is green, this being the colour of the curtains, the carpet and seat upholstery being of a dark olive tone. The metallic fittings are finished with mercurial gold.

The bedroom is entered by a side door in the partition between it and the bureau, while at the other end of the room one door leads direct to the bathroom and a second, on the other side of the coach, to the side corridor and the remaining compartments. The bedroom is decorated in the style of Louis XVI. It is finished in white enamel with carved enrichments in gold. The metallic fittings are mercurial gold, the bed, in ornate style, being of the same finish. The bed is 3 ft. by 6 ft. 6 in. The compartment is furnished with toilet table, wardrobe, and other fittings, in polished mahogany. The upholstery of the chairs is of old gold damask and the carpet of dark olive green. The widows have oxydised gun metal frames and louvre sun blinds, both being made to fall. The saloon, bedroom and bureau are fitted in addition with frames of sunshade glass.

The bathroom compartment is 8 ft. 7 in. long, panelled in Sundeala millboard, painted Wedgwood blue with white mouldings and enrichments. Spring blinds are fitted. The bath, table lavatory basin, and all metallic fittings are silver plated. The bath is silver-plated copper; it is placed across the compartment, and is arranged with spray and shower, with mixing valve for hot and cold supply for these and the plunge bath. The toilet basin is also fitted with hot and cold supply. The fittings comprise a silver-framed oval mirror and glass towel rails. The floor is laid with mosaic and drains towards the centre. The bath-room can be entered independently from the corridor.

The valet's compartment is finished in polished teak and has a light brown carpet and gun-metal fittings. It is arranged with a folding bed, wardrobe, folding lavatory basin, hinged table, cupboard, &c. It is entered from the side corridor. The attendant's compartment contains a folding seat, cupboards, wash basin and electric geyser for hot water supply. It is finished in teak and the floor is laid with Docker's Induroleum. It can be entered on one side from the corridor and end vestibule, and on the other by an outside door at the end of the coach side. In this compartment there is also an electric suction fan for the ventilating system of ducts throughout the coach.

The underframe is of steel, the sole bars being of 10 in. by $3\frac{1}{2}$ in. by 23·55 lb. channel section with the flanges turned inside. The sole bars are reinforced over the bogies by $\frac{7}{16}$ in. plates 10 ft. 9 in. long, 1 ft. 4 in. deep at the centre and tapering to the depth of the channel at the ends. The main cross bearers and the inside headstocks are of the same section as the sole bars. The outer headstocks are of 12 in. by $3\frac{1}{2}$ in. by 34·88 lb. channel section. The outer headstocks are shorter than the inner, the end platform being only 7 ft. $5\frac{1}{4}$ in. wide overall, compared with width over sole bars of 8 ft. 7 in. and overall width of frame of 9 ft. 1 in.

The main longitudinals are of the same section as the sole bars. The secondary cross bearers are 9 in. by 3 in. by 19·37 lb. channel; gusset plates are $\frac{1}{16}$ in. thick. The frame is fitted with four truss rods of $1\frac{3}{8}$ in. diam., and with diagonal cross bracing on the upper side of 4 in. by $\frac{1}{4}$ in. section. Compound buffers with rubber cylinders and arranged with compensating rocking levers and connecting links, ensure equal buffing resistance when rounding curves. The draw gear is continuous, with the screw link type of coupling.

The bogie frames are of $\frac{1}{2}$ in. plate with flanged openings pressed in them, and reinforced at the top and bottom by steel angles. The end members are of channel. The transoms are of steel channels with flanges facing inwards and packed with teak. The bolster is also of teak covered with $\frac{7}{16}$ in. steel plating. Rubbing plates are provided at the sides, with a clearance allowance of $\frac{1}{16}$ in. The ends of the bolsters are fitted with spring buffers pressing against $\frac{1}{2}$ in. plates fixed to teak blocks inside the side frames, the buffers and helical springs being recessed into the bolster. The bolster is fitted with a flat cup centre bearing and with specially lubricated side bearings. The spring plank is supported by two knife-edged yokes attached to two point suspension hangers which normally hang vertically. The bolster springs consist of two nests of triple elliptical laminated springs, hard rubber pads being inserted between the spring plank and the yokes to deaden any sound. The side springs are laminated and are fitted with rubber auxiliaries with hangers provided with compensating links. The bogie wheels are 3 ft. 9 in. on the tread and the wheel base 9 ft., the length over bogie headstocks being 14 ft. $11\frac{1}{2}$ in. The journals are 10 in. by $5\frac{1}{2}$ in., and from centre to centre the distance is 6 ft. 8 in.

The body framing is, as regards the floor, made up 9 in. by $3\frac{1}{2}$ in. side longitudinals and $3\frac{1}{2}$ in. by $1\frac{1}{2}$ in. centre longitudinal and transverse members. The pillars are $5\frac{1}{2}$ in. by $2\frac{1}{4}$ in. Tenons and joints are stiffened by knees, &c. The waist rail is 2 ft. 6 in. above floor level and cant rail 6 ft. $6\frac{1}{2}$ in. above the same. The height from floor to the top side of the inner carlines is 9 ft. $5\frac{3}{4}$ in., the sun roof carlines being 6 in. higher. The space between the two roofs at the cant rail is 4 inches. At this level a series of openings fitted with dust screens provides for a continuous flow of air between the two roofs.

The carriage is electrically lighted throughout with a very generous provision of lamps in the several compartments. The equipment includes two dynamos, and eight boxes of cells. The water for the bath, is electrically heated. The carriage is furnished with two 160-gallon water tanks over the bathroom and valet's compartments. End doors are furnished on each side with bronze steps, hand-rails, &c. The two lower steps are arranged to slide in under the end platform to clear the loading gauge. We hope to give, in a future issue, illustrations of this interesting vehicle.

Another feature of the stand of the Metropolitan Carriage Wagon and Finance Company, Limited, is the half of an English railway composite coach and brake van fitted up to show how readily standard English stock can be converted in the event of electrification. The section contains the complete equipment for a 1,500-volt standard main line coach as designed and constructed by the Metropolitan-Vickers Electrical Company, Limited, for the adaptation of existing stock to electrification. A model on the stand to $\frac{1}{16}$ in. scale is shown of a dining car—one of several built by the company for the Central Railway of Brazil. The firm also exhibits pressed, drop-stamped and forged steel work, while tyres, axles and solid steel disc wheels are shown from the works of Messrs. Taylor Brothers, Trafford Park Works, Manchester. One of the most interesting features of the stand is an original forging shown by the Patent Shaft and Axletree Company, Limited, of Wednesbury, whose patent for faggotting was taken out 60 years ago. The forging shows in a very instructive manner the

THE BRITISH EMPIRE EXHIBITION; VACUUM BRAKE FITTINGS.

(For Description, see page 541.)

Fig. 19. SECTION THROUGH E.F.

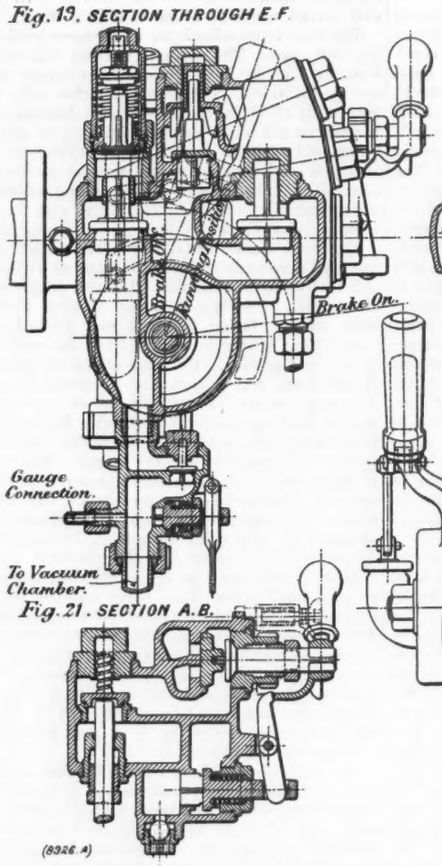


Fig. 20. SECTION THROUGH C.D.

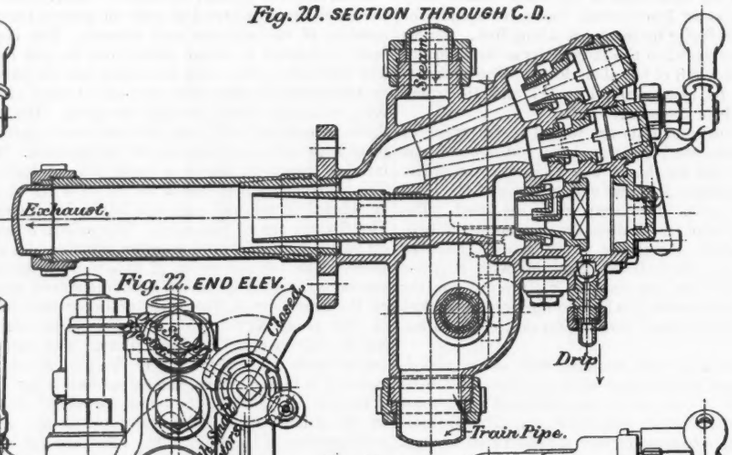


Fig. 22. END ELEV.

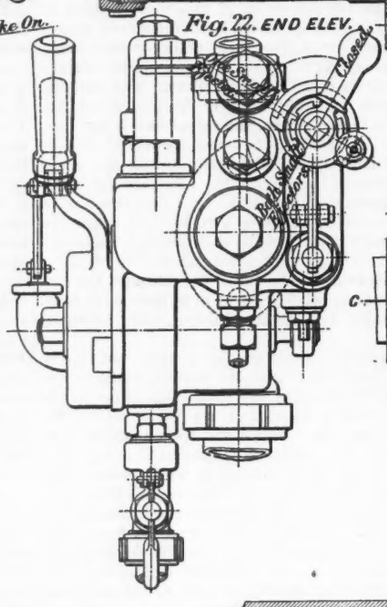


Fig. 23. PLAN.

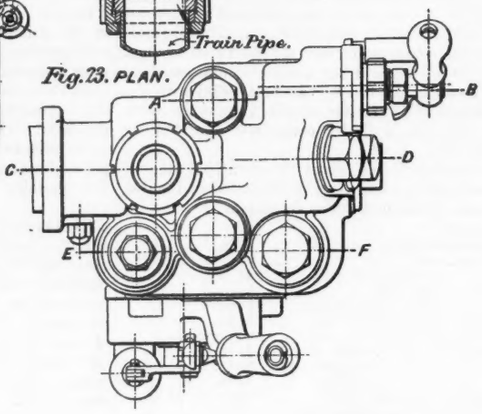


Fig. 21. SECTION A.B.

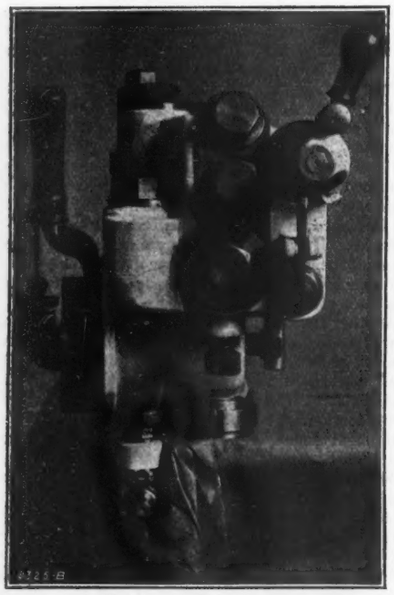


FIG. 24.

FIGS. 19 TO 24. SUPER-DREADNOUGHT EJECTOR; MESSRS. GRESHAM AND CRAVEN, LIMITED, MANCHESTER.

Fig. 25.

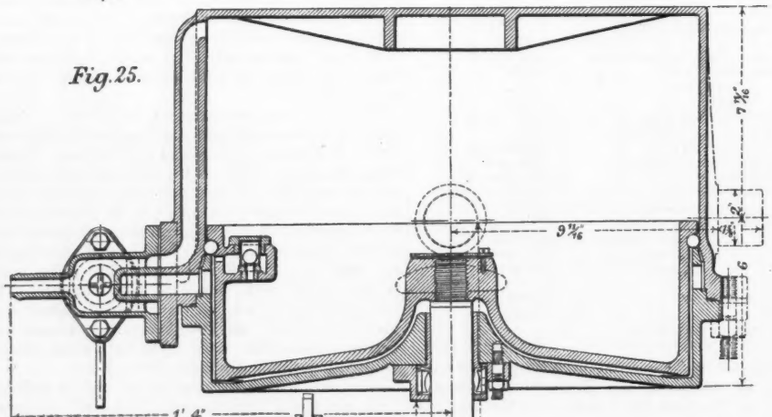


Fig. 26.

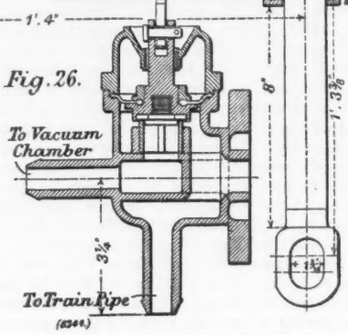
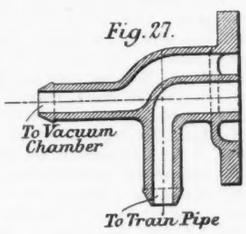


Fig. 27.



FIGS. 25 TO 27. VACUUM BRAKE CYLINDER; THE VACUUM BRAKE COMPANY, LIMITED, LONDON.

way in which axles were made by the firm's process from faggots of iron.

We should mention that examples of the use of the paints and varnishes of Messrs. Docker Brothers are to be found on view at various parts of the stand of the Metropolitan Carriage, Wagon and Finance Company, another example of whose work it may be noted is to be seen at the Stand of the Metropolitan Railway Company in the form of a control trailer to which we hope to refer at greater length on a future occasion.

Among rolling stock auxiliaries which are shown we may mention the Super-Dreadnought Ejector which embodies the latest of the many improvements made in recent years by Messrs. Gresham and Craven, Limited, of Ordsall-lane, Salford, Manchester, in connection with the automatic vacuum brake. The modification in this type of the features of the earlier Dreadnought pattern consists in the replacement of the single cone of 20 millimetre diameter with two of 15 millimetres diameter. When working with trains of average air tightness in the vacuum system, the use of one of these smaller nozzles is ample to overcome the leakage, but should the conditions be very abnormal, the two cones can be put into action together to meet the requirements. By splitting up the work between two cones, and arranging that they may be used together or separate, a nearer approach to the actual necessities may be made and in consequence, steam may be saved. The details of the equipment are shown in Figs. 19 to 23, on page 540, while Fig. 24 shows the appearance of a complete ejector assembled and ready for fitting. The two cones are operated by the same handle, by the turning of which one or both cones may be brought into action or shut off. A mechanically-operated air lock has been introduced in place of the previously-used ball valve device.

The Vacuum Brake Company, Limited, of 3 to 7, Old Queen Street, London, S.W.1, who work in association with Messrs. Gresham and Craven, Limited, in connection with the design and manufacture of the equipment for the vacuum brakes for railway trains, have introduced a new pattern of cylinder for the system which is illustrated in cross section in Figs. 25 to 27 on page 540. This type was designed to facilitate the examination and renewal of the roller ring and other parts, and in it is introduced a new form of release valve which can be fitted to face either way. In place of the usual top cover a bottom pan is provided, and thus it is possible to remove the piston from the cylinder without taking the body of the cylinder down, which is a great convenience, especially where heavy cylinders of large diameter are employed. The release valve is placed at the side to be convenient for the connection of the hose pipes to the train pipe and the vacuum chamber, while it is also quite out of the way of the main brake shaft lever. As this valve is reversible, in that it can be turned round with the branch to the train pipe in either direction, the necessity for having two patterns, one for each hand, is done away with. A distinct improvement introduced into the design of this cylinder is the provision of a guide for the rolling ring, which, in the event of the ring getting out of place ensures that it will return to its groove when the piston returns to its lowest position. A minor, but important, improvement is that the attachment of the piston rod to the piston has been strengthened to resist the tendency to bending of the rod.

An effective display of all their different classes of brake cylinders is made by the Vacuum Brake Company on their stand in the Palace of Engineering. They are assembled with their associated components in a complete vacuum brake installation in such a way that the action of the individual items may be demonstrated in operation and a complete system for either a steam or an electric train may be shown working.

AIR-COMPRESSING MACHINERY.—I.

For many services compressed air has remarkable conveniences, and particularly in connection with the use of pneumatic tools and for oil engines. The manufacture of air-compressing machinery has extended considerably during the last ten years or so. Such machinery is now built by a large number of British engineering firms, and a very adequate display of this class of plant is to be seen at the Exhibition. Of this we are for the present able to illustrate one example only, shown by Messrs. Belliss and Morcom, Limited, of Birmingham, which is typical of the several types manufactured by the firm. The machine, which is shown in Figs. 1 to 4, page 542 and Plate XLIII is a twin unit compressor designed specially to meet the requirements of motor ships, which, of course, have to carry auxiliary air compressors for starting or fuel injection purposes. Each line of parts forms a complete three-stage compressing unit which may be operated, if desired, independently of the other line. Air for each line is drawn in through a silencing branch, shown in section on the left-hand side of Fig. 3. It passes first through an air-regulator of the butterfly type and then through an automatic inlet valve into the top of the first stage cylinder. The first and third stage pistons compress, in an upward direction, and the second stage in a downward direction, thus giving a double-acting effect and equalising as much as possible the torque on the crankshaft. The second-stage cylinder is formed by an annulus between the trunk of the main piston and the first-stage cylinder. The piston rings throughout are of special cast iron, and the valves, which are of the disc pattern, are all readily accessible by the removal of their respective covers.

The air is cooled between each stage of compression, and also after the final compression, the cylinders, of course, all being water-jacketted in addition. The coolers are arranged in a single casting bolted to the back of the machine. They consist of sets of vertical tubes, through which the air passes, the cooling water being circulated round the outside of the tubes and directed by baffles to ensure the fullest utilisation of the cooling surface. Large and efficient separators collect any moisture or emulsified oil, which may be carried by the air. Forced lubrication is applied to all motion work, oil pressure being maintained by an external pump of the gear type driven by a flexible coupling from the free end of the crankshaft. The crank chamber does not form an oil-well, but is of the dry-sump type. The lubricating oil coming from the bearings, drains away into an external tank in which it is filtered and from which the pump draws its supply.

The compressor illustrated is capable of compressing 400 cub. ft. (11·3 cub. metres) of free air per minute to a pressure of 1,100 lbs. per square inch (77 kg. per sq. cm.) when running at a speed of 375 r.p.m. Four standard sizes of this type are built, with capacities respectively of 150, 200, 300, and 400 cub. ft. of free air per minute. Intermediate requirements can, of course, be met by adjusting the speeds. The design of these compressors is the result of many years of experience of high-speed engine and compressor building, and particularly of the experience with compressors fitted to Messrs. Belliss and Morcoms' Diesel engines. The compactness of the design renders the machines particularly suitable for shipboard work, but the same characteristic is often equally valuable on land, particularly as the accessibility of the parts has in no way been sacrificed.

ELECTRICAL MATERIAL.—I.

We have already explained in our general introduction that our selection of exhibits for illustration and description in this number is very far from being exhaustive. The reasons we have given sufficiently explain this matter, but none the less, we are conscious that the omissions are particularly marked in this electrical section. The field covered by electrical work has, however, become so wide and so important that in no way could it have been covered properly in one issue. The particular type of exhibit to which we are, for the moment mainly restricting ourselves has, however, a special claim to consideration and prominence, as it represents a comparatively recent and very important development on the part of some of our leading electrical firms. Corresponding exhibits of some of the other firms we will hope to deal with later.

The type of exhibits to which we refer illustrates one of the most satisfactory features of present-day electrical manufacturing in this country. No great number of years ago little attention appeared to be paid by British firms to the manufacturing side of hydro-electric developments, and although a great deal was being done in connection with the application of water power in our Dominions and India, as well as in foreign countries, we appeared content to allow the necessary machinery to be purchased entirely either on the Continent or in America. In late years, however, a great change has come over the practice of some of our large firms in this connection, and several of them have not only made arrangements to undertake the building of hydro-electric machinery, but have obtained many important orders and have carried them out in a very satisfactory manner. Notably among these firms is to be named the English Electric Company of Queen's House, Kingsway, London, W.C. 2, and their Wembley exhibits to which we refer illustrate two of the important hydro-electric contracts with which they have been recently associated. They show duplicate parts both of a series of 30,000 h.p. twin-wheel impulse turbines, which they are supplying for the Behira power station of the Tata Company in India, and of a 25,000 h.p. reaction turbine which they have recently shipped to South America.

The South American turbine, which is being erected in the Sorocaba power station of the Sao Paulo Power Company of Brazil, is illustrated in Figs. 1 to 7 on Plates XLIV and XLV. The general arrangement of the set as it will be erected in the power station is shown in Figs. 1 to 3, while two views of the runner are given in Figs. 4 and 5, and views of the casing completed and in process of machining in Figs. 6 and 7. The machine has an output of 25,000 h.p., works under a net head of 650 ft. and has a speed of 600 r.p.m. That a machine of this capacity, built to work under these conditions, must involve many interesting problems in its design is illustrated by the fact that the Sorocaba turbine has to work under a pressure of 20 atmospheres, and has to discharge through its runner 400 cubic ft. of water a second at a velocity of not less than 48 ft. per second. Some interesting considerations arise in connection with the clearance between the runner and the casing. Owing to the relatively large dimensions and to high pressure a small clearance only is permissible in order to avoid undue water losses, and with such a small clearance it is essential that the runner should not move longitudinally relative to the casing. Apart from possible purely mechanical movements which might affect this small clearance if a specially rigid construction were not employed, the heat generated in the alternator when under load would be sufficient to affect the clearance owing to the resultant extension of the shaft. These conditions have been met by, in the first instance, carrying the generator and turbine casing on a common bedplate. As will best be seen from Fig. 2, the generator bedplate is formed with a forked extension at the turbine end on to which the spiral casing is bolted. Further, the turbine casing cover has been connected to the main centre bearing with two heavy bolts, making the bearing and cover practically one solid piece. This centre bearing is the thrust bearing of the machine, so that any expansion of the generator shaft takes place in the direction of the outboard bearing and does not affect the runner clearance.

It is necessary that the clearance between the runner and the casing should be adjustable, and to allow of this two forged steel rings are secured to the runner, with their outer faces shaped in section like a comb. These can be seen in Figs. 4 and 5. The casing carries two other rings with corresponding comb faces, which engage with the moving combs on the runner and thus form a sort of labyrinth joint. The fixed rings are adjustable by means of screws, and by setting their position properly water leakage may be reduced to a minimum. The arrangement allows of setting-up and maintaining the original clearance even after the rings are worn a little. The runner itself is made of bronze, the choice of this material being dictated by the necessity of avoiding corrosion, which might be induced by the high suction head and the high velocity of the water.

An air-snifting valve is fitted on the draft tube bend, and can be seen in Figs. 1 to 3. The purpose of this is to avoid undue suction in cases of a sudden closing of the gate apparatus. In such cases practically no

THE BRITISH EMPIRE EXHIBITION; AIR COMPRESSOR FOR MOTOR SHIPS.

CONSTRUCTED BY MESSRS. BELLISS AND MORCOM, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Page* 541.)

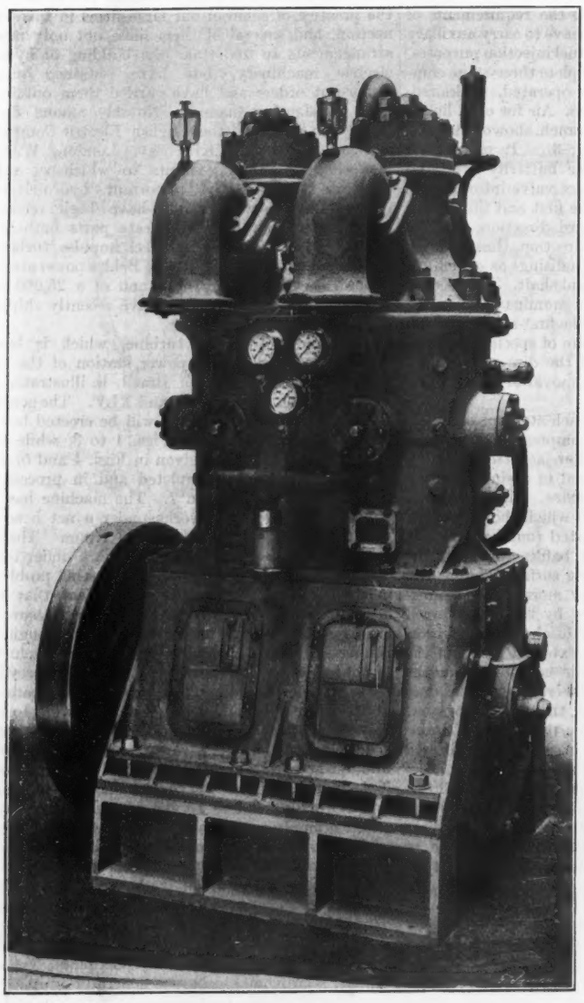


FIG. 1. AIR SUCTION SIDE OF COMPRESSOR.

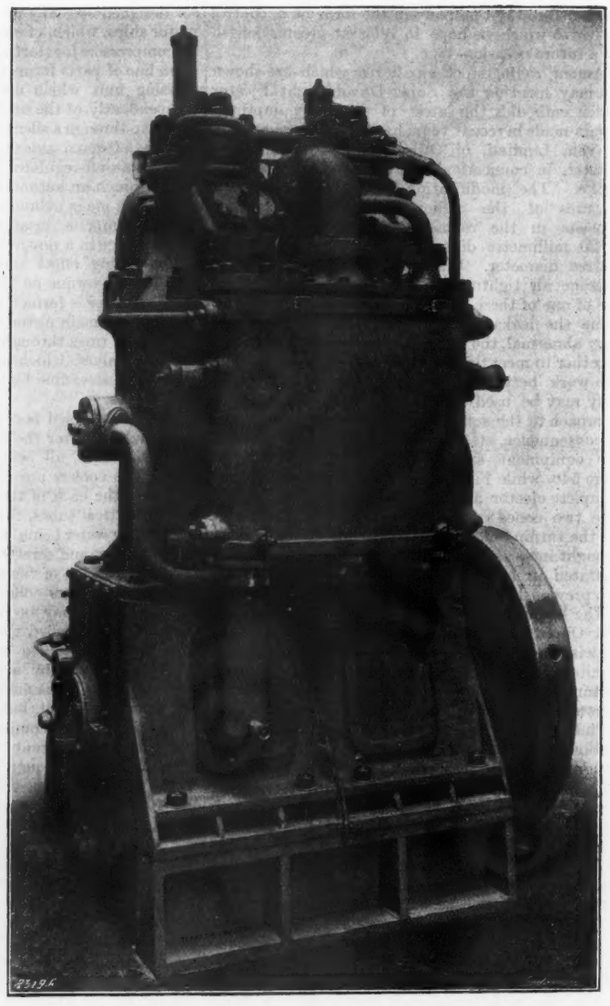


FIG. 2. INTER-STAGE COOLER SIDE OF COMPRESSOR.

water can pass through the gate apparatus, but the flow through the draft tube cannot be quickly checked, and as a result a vacuum might occur in the tube which, in the absence of the air-snifting valve, could only be destroyed by a backward movement of the water or a sudden change in the velocity of the runner. The snifting valve is controlled by the governor, but it is also capable of opening of itself if, for any reason, the governor control fails to operate. Quick closing of the valve is prevented by a dashpot. Equalisation of pressure on the two sides of the runner during normal working is ensured by the equalising pipe, which, as can be seen in Figs. 2 and 3, connects the spiral casing with the draft tube.

The spiral casing has the form of a logarithmic curve, which ensures the same entrance velocity for the water all round the gate apparatus. The casing is of a very strong and well stiffened construction. The pressure due to the water coming from the pipe line is about 500 tons, and a special design of anchored joint is used on the line just before the main sluice valve. The rigidity of the whole machine is further secured by the common bedplate and the connecting stays between the casing and the centre bearing to which we have already referred. The regulating arrangements consist of a governor and an oil-pressure servo-motor, the supply to which comes from an oil-pressure tank. The governor has an adjustment of from 0 to 5 per cent. of the permanent speed variation between full and no load, and may be adjusted either by hand or electric motor. There is an automatic safety device for shutting down the set for a speed of ± 30 per cent. above or below normal to take care of cases of runaway or breakage of the governor belt.

The oil-pressure tank is fed by an oil pump driven by a little impulse wheel. In order to save energy an automatic device has been arranged between the pump and the tank which, when the pressure in the tank reaches 16 atmospheres, opens a connection to the oil storage tank below and partially closes the turbine inlet. The turbine then runs unloaded. When the pressure in the oil-pressure tank drops below 14 atmospheres the automatic valve again operates, connecting the oil supply to it and re-opening the spear valve of the impulse wheel. This arrangement saves power and prevents unnecessary wear and tear on the pumping set.

The English Electric Company's other hydro-electric exhibit illustrates one of the sets of twin impulse turbines supplied to the Behira power station of the Tata Company. Each twin machine, has an output of 30,000 h.p., runs at a speed of 375 r.p.m., and works under a net head of 1,630 ft. Each twin set is fed by two separate pipe lines which are fitted with two cylindrical balanced valves, one of which can be seen in Fig. 8, Plate XLV, and 10, page 543. These are controlled by a differential servo-motor, operated by the pressure water from the pipe line. A balanced valve has many advantages for work of this kind and requires but a small force for its operation. One of the chief features of the English Electric balanced valve is its control by a travelling control valve, which automatically slows the movement when the main valve is nearly closed, so that there is no sudden final stoppage, and water hammer is prevented. This travelling control valve consists of a chrome-nickel screw attached to the piston of the valve. The pressure water which is to operate the servo-motor traverses the threads of this screw, and matters are so arranged that towards the end of the stroke when closing a greater length of screw has to be traversed by the water. This results in an increase in friction losses and a reduction in the rate of flow, so that the speed of movement of the servo-motor is slowed up.

The inlet bends and nozzles of the turbine are arranged with Seewer regulation, which acts by first destroying the energy of the jet by the introduction of a blade into the stream. This deflects

(To face page 542.)

THE BRITISH EMPIRE EXHIBITION; TWIN THREE-STAGE AIR-COMPRESSORS FOR MOTOR SHIPS.

CONSTRUCTED BY MESSRS. BELLISS AND MORCOM, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Page* 541.)

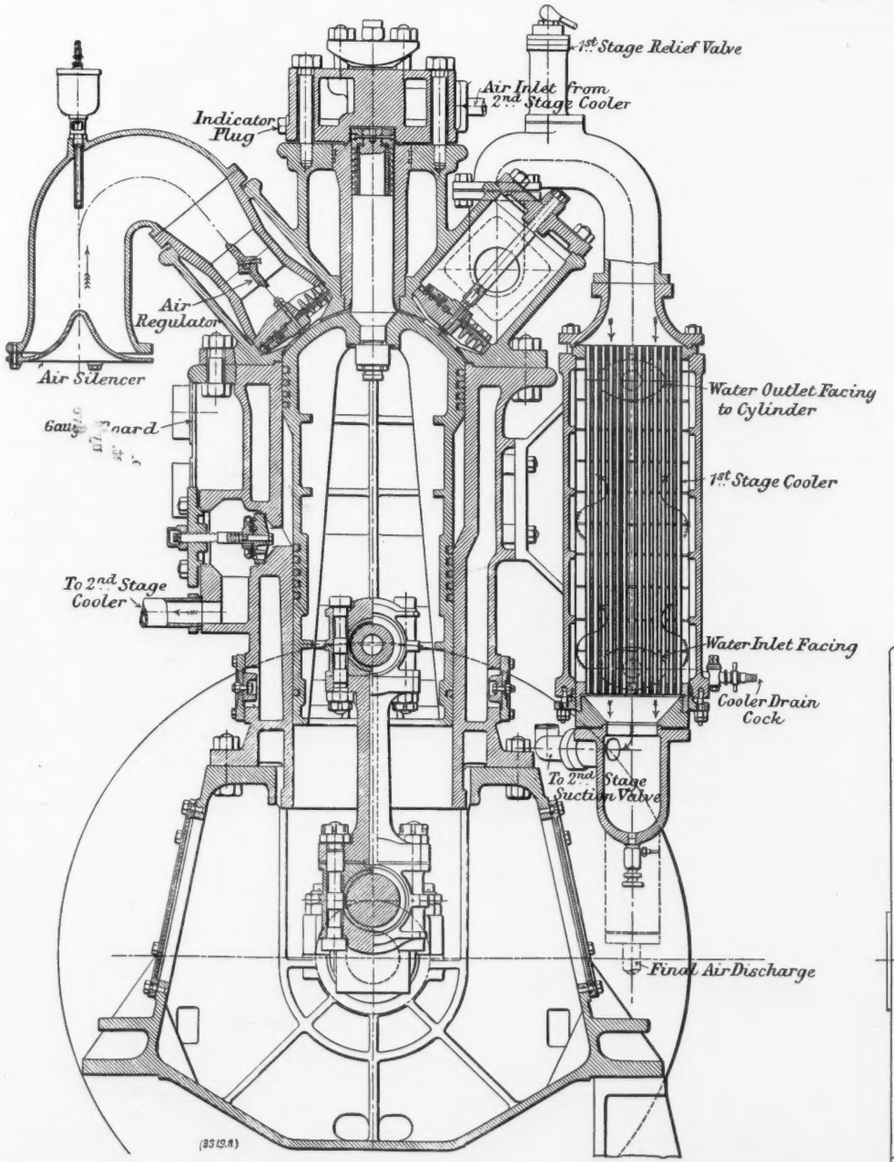


FIG. 3.

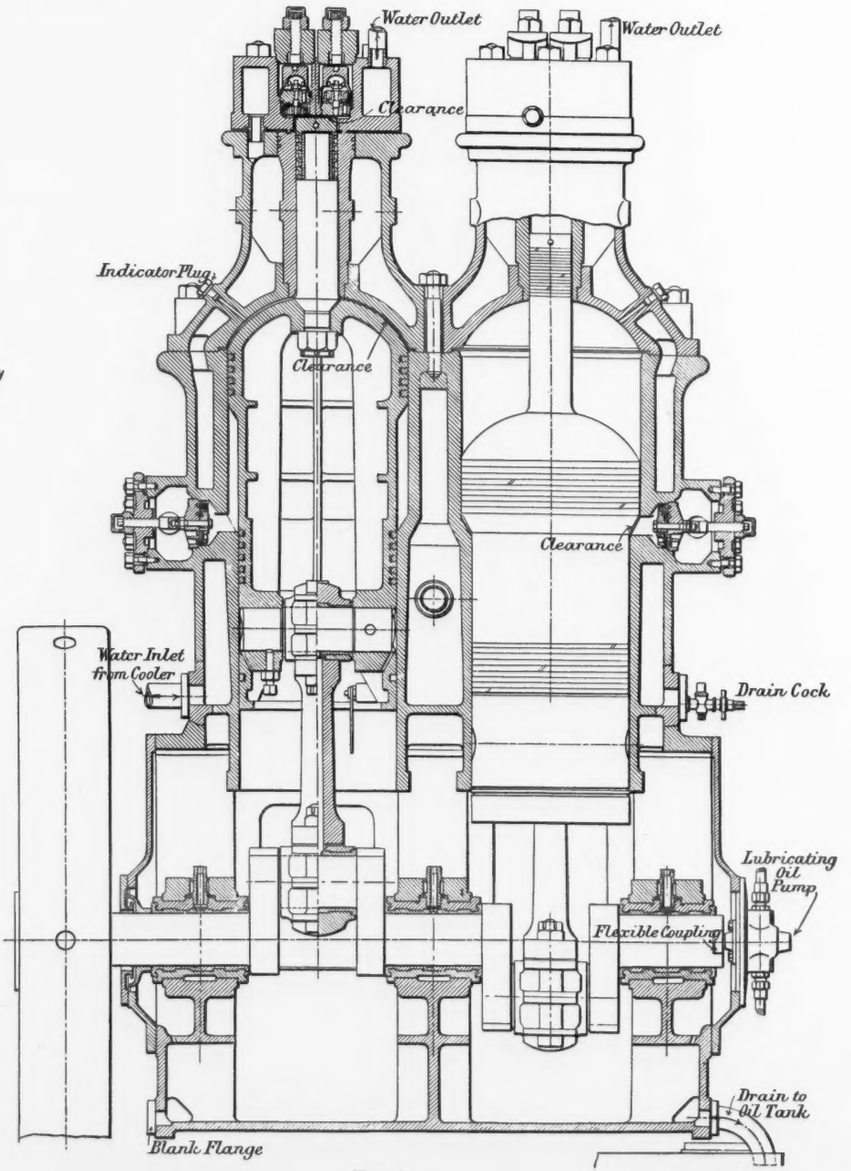


FIG. 4.

THE BRITISH EMPIRE EXHIBITION; 25,000-H.P. HYDRAULIC TU

CONSTRUCTED BY THE ENGLISH ELECTRIC COMPANY,

(For Description, see Page 54

Fig. 1.

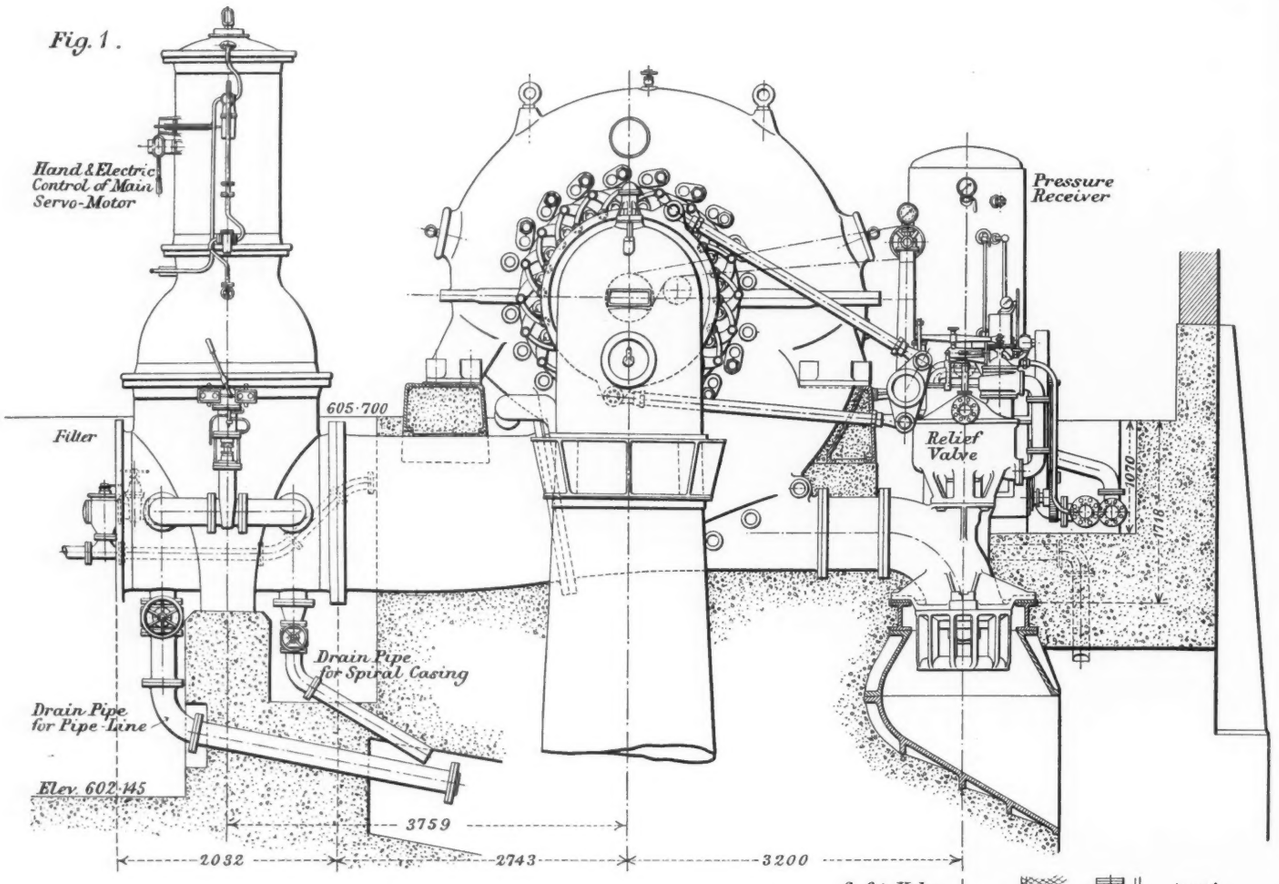
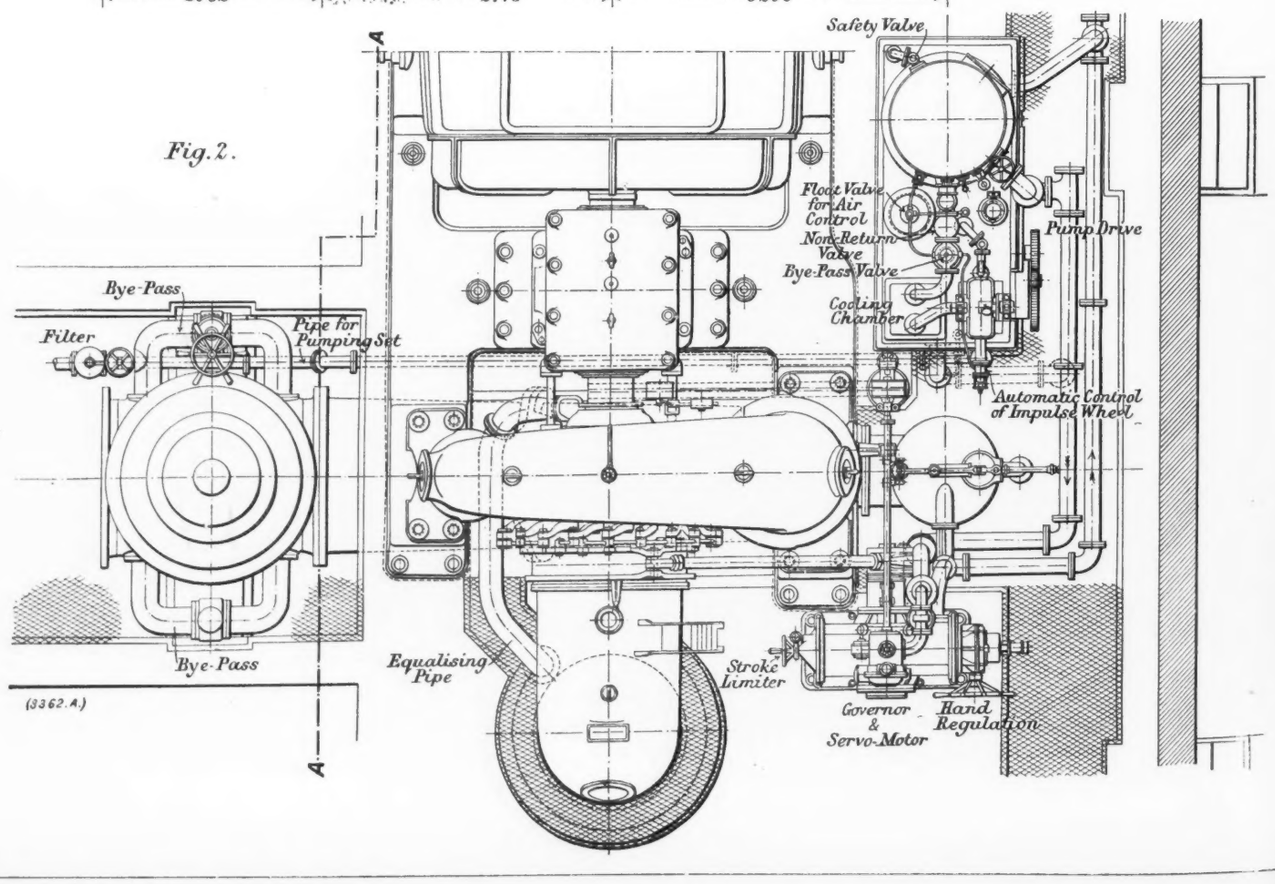


Fig. 2.

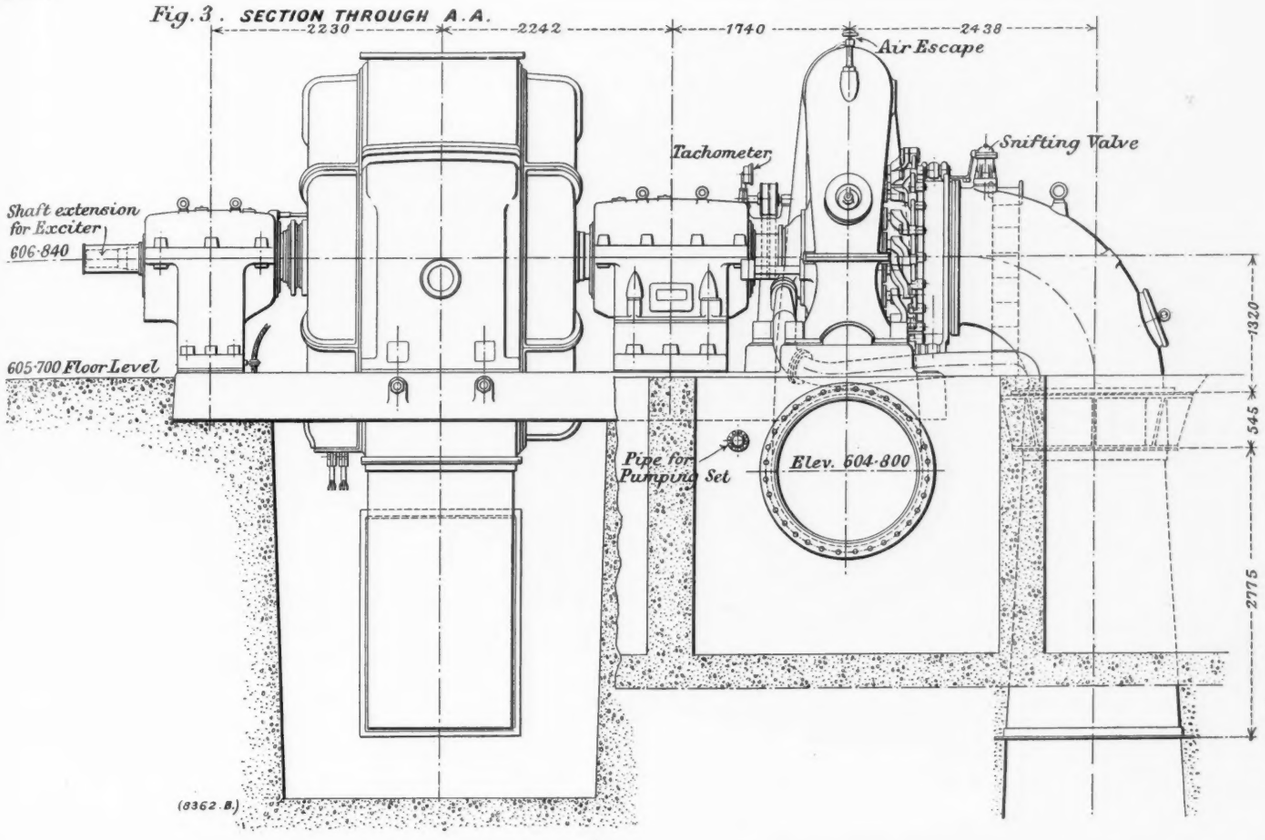


RAULI TURBINE FOR SOROCABA POWER STATION, BRAZIL.

ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON

(Description Page 541.)

Fig. 3. SECTION THROUGH A.A.



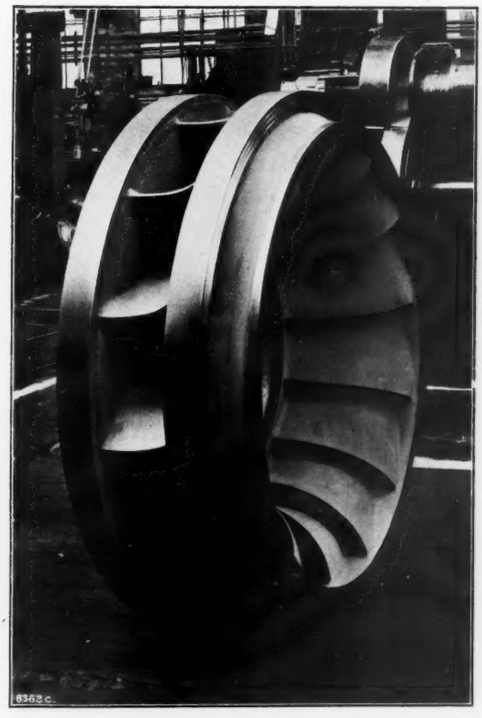


FIG. 4.

FIG. 5.

THE BRITISH EMPIRE EXHIBITION; HYDRAULIC TURBINES.

CONSTRUCTED BY THE ENGLISH ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON.

(*For Descriptions, see Pages* 541 *and* 542.)

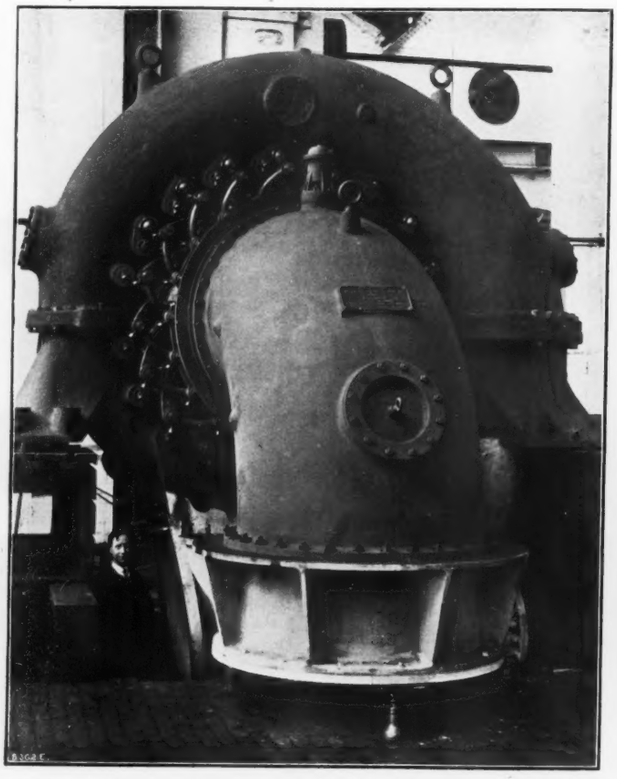


Fig. 6. Casing and Draft Tube for 25,000-H.P. Turbine.

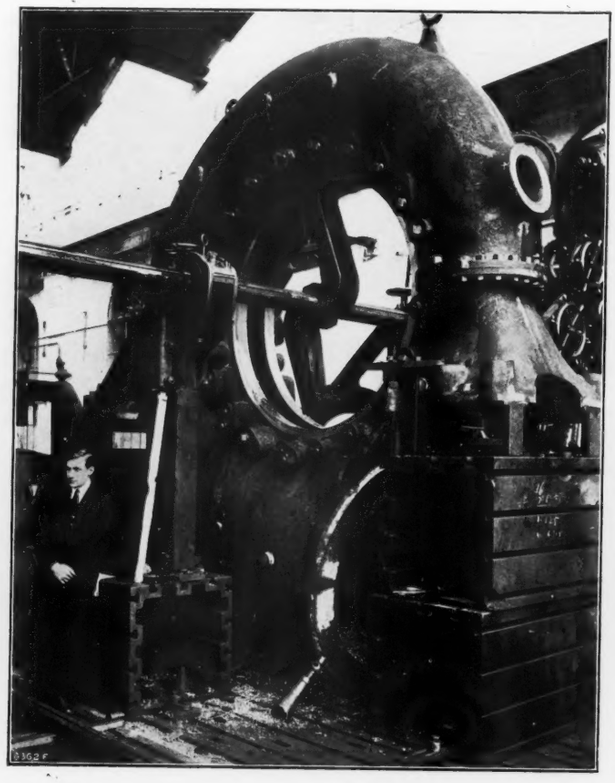


Fig. 7. Machining Casing for 25,000-H.P. Turbine.

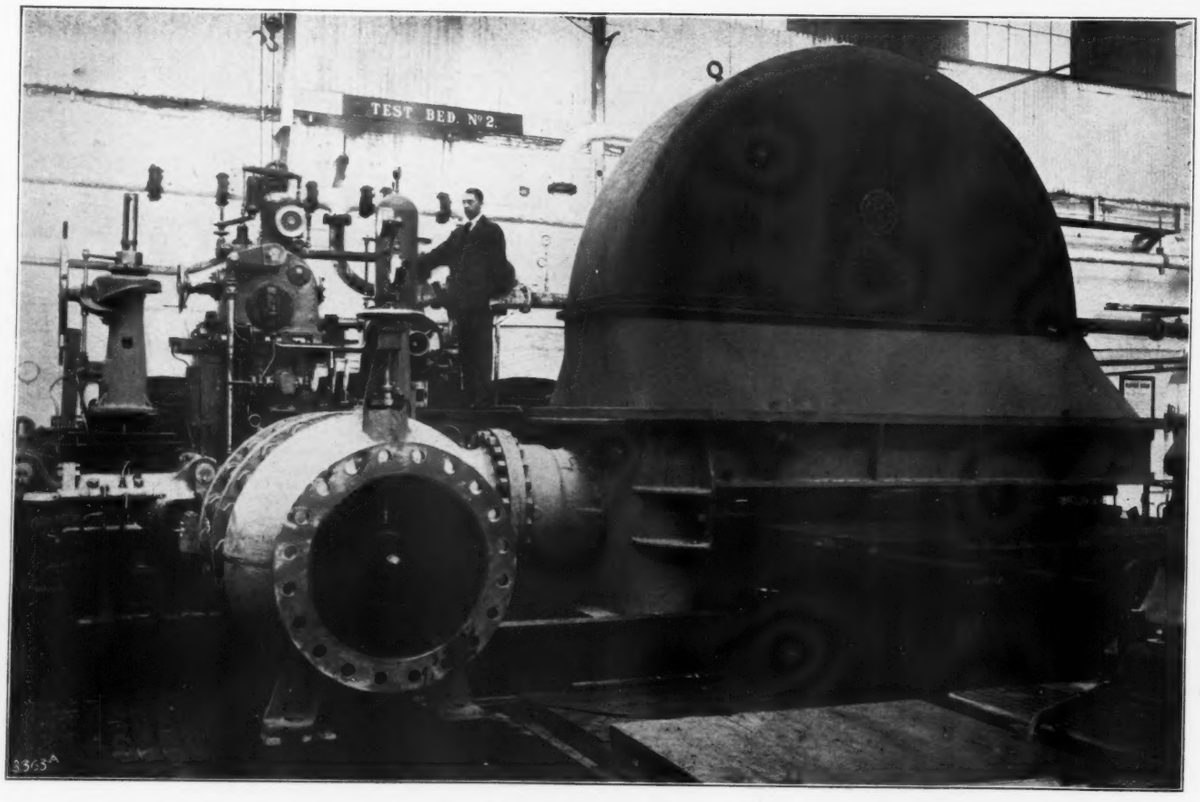


Fig. 8. 30,000-H.P. Twin Turbine.

(*To face page* 543.)

much of the water from the wheel buckets. Following this action the spear closes slowly in order to prevent any undue pressure rise. The inlet bend is attached to the turbine bedplate, while this latter is provided with a machined flange for connection with the generator bedplate. With this arrangement the jet issuing from the nozzle can be exactly centred on the wheel, although the wheel is overhung at the end of the generator shaft. A similar wheel to that fitted to the Behira turbines is shown in Fig. 9.

As will be seen the buckets are each attached by a single bolt and key. The bolt is conical and fits tightly in a split bush, while every alternate key is machined out of the solid disc. By this means a very strong and reliable attachment is secured. The bolts work under tensile stresses and the keys under compression.

One governor is fitted for the control of two turbines. It is situated between them in a position to ensure the same amount of regulation at the two

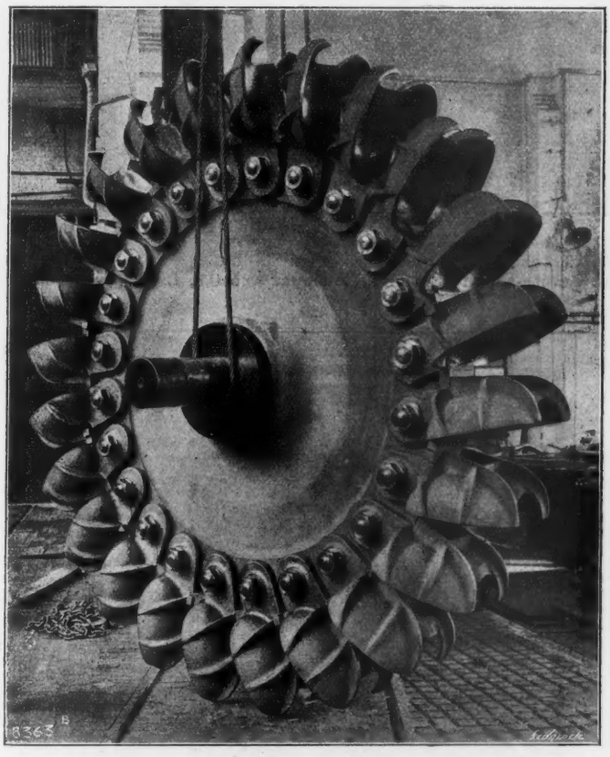


FIG. 9. PELTON WHEEL FOR 30,000 H.P. TWIN-TURBINE; THE ENGLISH ELECTRIC COMPANY, LIMITED.

bends. It is belt driven and is provided with double compensation, may be permanently adjusted for speed variation, and is controllable either by hand or electric motor. There is an automatic speed device for shutting down the set for speed variation of plus or minus 30 per cent. above or below normal to take care of runaway or the breakage of the governor belt. The pressure oil is supplied by a two-stage rotary pump and is stored in an oil-pressure receiver, from which, according to the position of the distributing valve, it is led to one side or the other of the servo-motor. This servo-motor controls two regulating shafts transmitting the movement to the Seewer diffuser of the two turbines. The diffusers in their turn control the spear servo-motor by means of distributing valves. The oil on its way from the distributing valves to the servo-motor flows through regulating screws of the same type as those used in connection with the movement of the balanced valves. By this means a very fine adjustment of the closing time of the spear is obtained.

Leaving any further descriptions of heavy electrical plant for future issues we may now deal with one or two of the smaller electrical exhibits which are to be seen at Wembley. We may first refer to an interesting photometer which is shown on the stand of Messrs. Everett, Edgcumbe and Co., Limited, of Collindale Works, Hendon, and of which views are given in Figs. 11 and 12 on page 544. This instrument is intended for the measurement of mean spherical candle-power. At one time the mean horizontal candle-power was almost universally employed for the comparison of lamps, but since the introduction of gas-filled lamps and the advance in the general study of illumination questions, it has been realised that the horizontal candle-power may have but little relation to the value of a lamp for illumination purposes. The mean spherical candle-power, that is, the average candle-power in all directions, which is, of course, a direct measure of the total output of light, is now utilised as a means of comparing lamps.

The photometer illustrated in Figs. 11 and 12 is intended for the direct measurement of this mean spherical candle-power or luminous flux. The instrument, which is known as a cube photometer, owes its practical development to the fact that a lamp enclosed in a chamber of regular conformation, suitably dimensioned and provided with a highly diffusing inner surface, will illuminate the whole of that surface equally and to an extent proportional to the luminous output of the lamp. The result is that the mean spherical candle-power or the lumens emitted by the lamp can be directly determined by measuring the brightness of a selected part of the inner surface. Although the basic principle of this instrument is so simple much care and consideration have been necessary to produce a design which will really give accurate results.

Of our two illustrations, the first, Fig. 11, shows a form of the cube photometer specially adapted for use in lamp works or in other places where a large number of lamps have to be tested in succession. It has a double door arrangement, each door carrying a lamp holder, as shown in the figure, so that when one door is closed and the lamp it is carrying is under test, the next lamp can be inserted in the holder on the second door, which is open so that its holder is outside the cube. Both doors are shown open in the figure. The second illustration shows the cube in use with a bar photometer, the actual photometer head shown being Messrs. Everett, Edgcumbe's combined screen and flicker head. Any other head, such as the Lummer-Brodhun, can, however, equally well be used.

Although the last ten years or so have shown remarkable advances throughout almost the whole range of electrical work, probably no individual class of plant or apparatus has progressed to a greater extent than switchgear. This has partly been due to the general development of design and improvements in insulating materials and partly to demands which have arisen which could not well be satisfied by some of the earlier designs. The great extension in the use of alternating current distribution at pressures up to 11,000 volts and the construction of substations in manufacturing works for conversion from such a pressure to one more suited for general motor driving throughout a factory, has created a demand for 11,000 and 6,600-volt works substation boards in very large quantities. Such boards have usually to be placed in buildings not specially constructed for the purpose and a self-contained type of gear not dependant in any way on the walls of the building, or on specially erected cubicle constructions, offers great advantages.

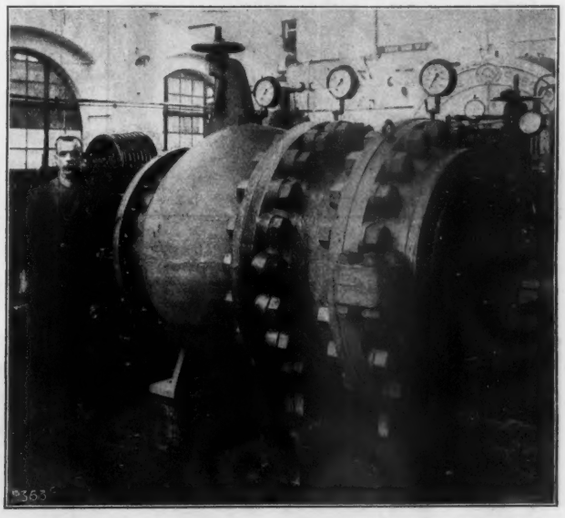


FIG. 10. BALANCED VALVE FOR 30,000-H.P. TWIN TURBINE; THE ENGLISH ELECTRIC COMPANY, LIMITED.

These conditions and considerations have led to the development of self-contained designs of high-tension switchgear of considerable interest, and an example of such a design which has been developed by the English Electric Company, Limited, of Queen's House, Kingsway, London, is to be seen on the firm's stand at Wembley. The gear is illustrated in Figs. 13 and 14, on page 544. It will be seen that the gear is of the truck type, each panel consisting of a framework built up of sheet-iron and sections and carried on four wheels, which fits inside a fixed portion. The fixed parts of the panels are bolted together and from a bus-bar chamber at the back of the board. The bus-bar chamber is separated from the panels by an insulating and fire-proof partition, and connection between the bars and the panel is made by contacts carried in porcelain insulators on the back of the truck. These contacts fit into jaws carried by porcelain insulators in the bus-bar chamber. Below the bus-bar chamber and separated from it by a horizontal insulating partition, there is a chamber containing a second set of jaws, which engage the lower set of contacts on the truck. These contacts and jaws make connection with the outgoing circuit from the panel, and the fixed chamber is of sufficient dimensions to allow of a cable box being fixed below the contacts.

One great advantage of this gear, apart from the conveniences of its self-contained nature, is that it is at no time necessary to obtain access to its back, so that it can be mounted directly against a sub-station wall. This not only saves space, but eliminates the narrow and not always safe inspection

THE BRITISH EMPIRE EXHIBITION; ELECTRICAL MATERIAL.

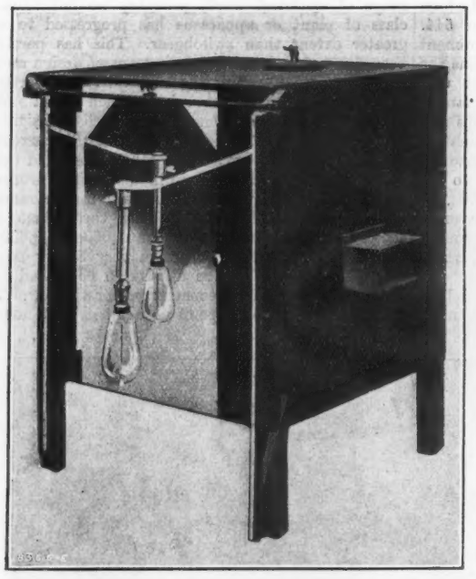


FIG 11.

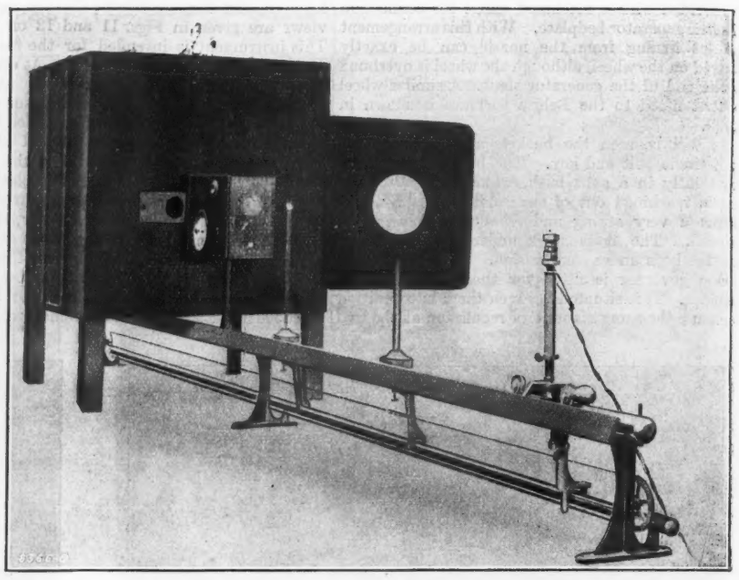


FIG. 12.

FIGS. 11 AND 12. CUBE PHOTOMETER FOR MEASURING MEAN SPHERICAL CANDLE-POWER; EVERETT, EDGCUMBE AND CO., LIMITED, HENDON.

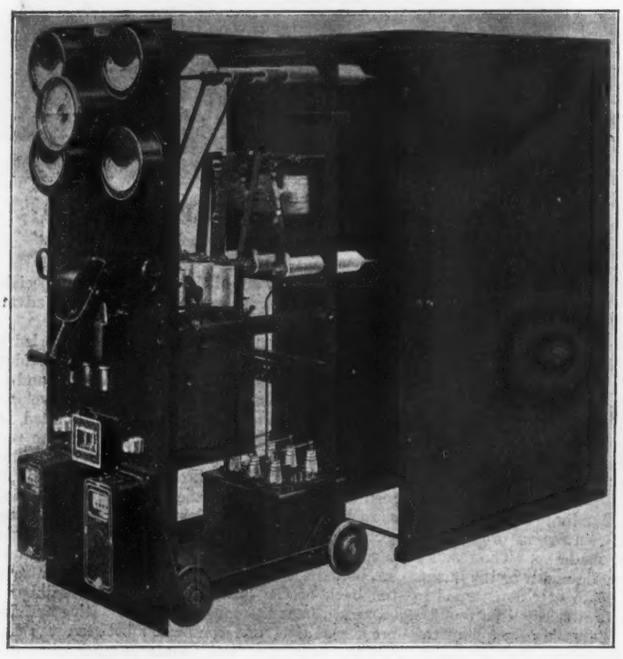


FIG. 13.

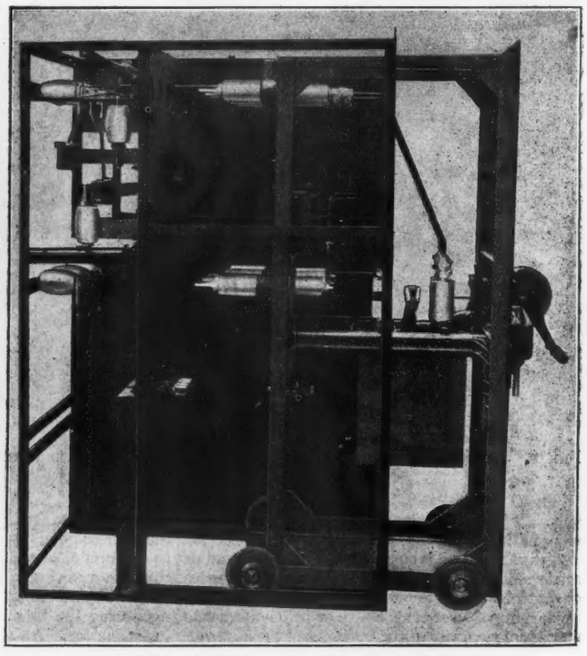


FIG. 14.

FIGS. 13 AND 14. TRUCK TYPE 6,600-VOLT SWITCHGEAR; THE ENGLISH ELECTRIC COMPANY, LIMITED, LONDON.

passage which is not infrequently found behind high-tension substation switchboards. A further important advantage of the arrangement is that when the trucks are pulled out from the board, they are completely open for inspection and repair from three sides. This greatly facilitates working on the apparatus and is clearly much more convenient than working on a cubicle type panel from the front side only. As the truck carries the oil circuit-breaker and all instruments and instrument transformers, it contains all apparatus which is at all likely to require repair, and as the trucks are themselves interchangeable, trouble which may arise may be dealt with without a delay of more than a moment or two by removing the defective panel, and substituting a spare in its place. It is not necessary to carry a large number of spare panels to take full advantage of this facility, as all panels up to 500 amperes carrying capacity are duplicates in their current-carrying parts. This range will cover by far the greater part of all panels likely to be installed in the situations for which this gear is especially intended. In many situations this feature of the gear could be taken advantage of even when no spare panel was carried, by substituting the panel of some unimportant circuit, or one which was out of service, for that which was giving trouble. It should be said that rails are provided inside the fixed portions of the panels on which the wheels of the truck portions run. This enables proper interchangeability to be obtained and the meshing of the fixed and moving contacts is not affected by local irregularities of the floor.

These panels of the English Electric Company are standardised for 600, 3,300, 6,600 and 11,000 volts, the current capacity of the two higher voltages

THE BRITISH EMPIRE EXHIBITION; TELEPHONE APPARATUS.

CONSTRUCTED BY MESSRS. S. G. BROWN, LIMITED, ENGINEERS, ACTON.

FIG. 15.

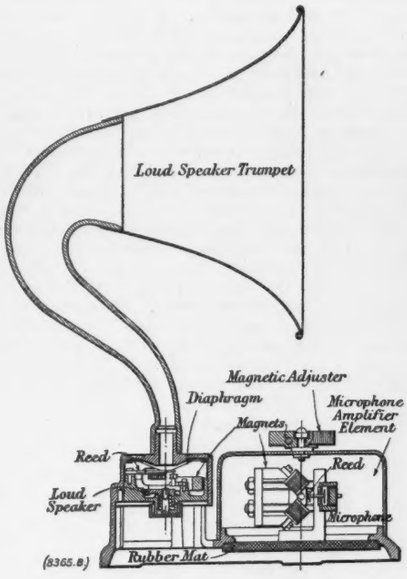


FIG. 16.

FIGS. 15 AND 16. "CRYSTAVOX" COMBINED AMPLIFIER AND LOUD SPEAKER.

FIG. 17.

running up to 600 amperes and of the two lower to 1,200 and 1,000 amperes respectively. The standard panels are arranged for three-phase circuits, but two-pole panels for single phase circuits can be provided if necessary. The panels contain loose-handle oil circuit-breakers, which can be fitted with overload and no-volt coils, and can be arranged either with a mechanical time-limit device, or with simple shunting of the overload coils with fuses. There is plenty of room for potential and current transformers in the panels and any reasonable com bination of instruments can be fitted. The fixed portions of the panels are so designed that a second bus-bar chamber for a set of duplicate bars may be supplied if necessary. It should also be said that automatic shutters are provided which, when a truck is withdrawn, cover the holes in the bus-bar chamber shield through which the connection from the oil-switch pass. The result of this is that no live part is exposed in the empty panel when a truck has been withdrawn.

Other electrical apparatus of the lighter types is displayed by Messrs. S. G. Brown, Limited, Victoria-road, North Acton, W. 3, that of most importance to our readers being the firm's gyro compass for ships, but as we have already illustrated and described this apparatus very fully on page 202 of our issue of February 13, 1920, we must refer our readers to that article for further particulars. Messrs. S. G. Brown are, of course, large manufacturers of telephone apparatus, both for use in connection with the reception of wireless telephony and for line working, and of their exhibits of this class of apparatus we may first refer to the Frenophone. This instrument is a novel form of loud speaking receiver invented by Mr. S. G. Brown, and developed particularly for the reception of broadcast telephony. It is operated by the friction between a rotating glass disc, driven by a clockwork motor, and a small steel button faced with cork, which rests on the glass. The button is held in position by a light spring and is connected by a silk cord to the centre of a large diaphragm. The telephone currents are supplied to a receiver of the Brown reed type, and the vibrations of the reed are made to vary the pressure between the cork-faced button and the glass disc. The pressure variations cause the button to be dragged along by the movement of the glass disc, to an extent which is proportional to the pressure, and in this way the vibrations of the reed are reproduced on a larger scale by the motion of the button. The latter, as already mentioned, is connected to a diaphragm which is thus caused to vibrate and to set up corresponding vibrations in the air in a horn or trumpet with which it is in communication. By this means a large volume of sound of good quality is produced. We should, perhaps, mention that to increase the friction between the cork pad and the glass, the latter is treated with a special tacky solution before the instrument is used.

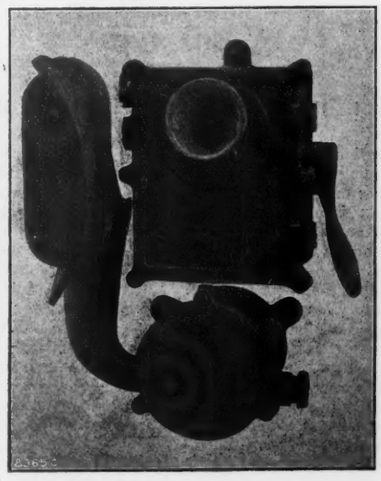


FIG. 18.

FIGS. 17 AND 18. LOUD-SPEAKING LINE TELEPHONE APPARATUS FOR SHIPS, &C.

The firm's exhibit also includes a variety of their well-known loud speakers, in which a thin spun-aluminium diaphragm is actuated by the vibration of a stiff steel reed, which forms the armature of the telephone magnets. In these instruments, the sensitivity can be adjusted by moving the magnets, by means of a fine pitch screw, so as to vary the air gap between them and the reed. For use when the received telephony is of insufficient strength to operate a loud speaker directly, or when for other purposes it is desired to magnify weak telephone currents, the firm supply a microphone amplifier, in which the weak currents are made to operate a small carbon-granule microphone. This controls the flow of current in a local circuit in which a primary battery and the loud speaker are included. Fig. 15 annexed shows the external appearance of the "Crystavox" loud speaker exhibited by Messrs. Brown, this instrument being a combination of a specially sensitive form of microphone amplifier and a loud speaker, and having been designed for use with a crystal receiving set without the necessity for employing valves for audio-frequency amplification. The construction of the instrument is shown in the sectional drawing reproduced in Fig. 16. The parts are mounted on a cast-metal base, the amplifier unit, shown on the right of Fig. 16, being placed on a rubber mat and provided with a removable cover. The weak currents from the crystal receiver pass through coils mounted on the pole pieces of a permanent magnet, and the resulting flux variations set up forced vibrations in a steel reed, which is directly connected to the small microphone shown to the right of the angle bracket in Fig. 16. A bar magnet is embedded in the milled disc on the top of the cover, and this can be turned to vary the flux in the main magnet by induction, and thus to adjust the sensitiveness of the amplifier. The microphone is connected in series with the magnet coils of a loud speaker of the type described above, and current from a 6-volt dry battery is supplied to this circuit through the two terminals seen in Fig. 15. The current fluctuations set up by the variations in the resistance of the microphone due to the vibration of the reed are sufficient to operate the loud speaker, and as the steady current is only about

30 milliamperes the life of the dry battery is considerable.

There are numerous applications on ships, and in works, power plants, and other industrial establishments, for a loud-speaking line telephone by which communication can be maintained in noisy situations and instructions can be given so that they can be heard at a considerable distance from the receiver. An instrument for this class of work, known as the "Electro-Megaphone," manufactured by Messrs. S. G. Brown, forms part of their exhibit, and the half-tone engraving, Fig. 18, page 545, shows the appearance of a combined transmitting and receiving set. With this instrument, it is stated, a person speaking in an ordinary voice into the transmitter can be heard in the open air, at a distance of 60 yards from the receiver.

For each transmitter two differential microphones, connected in parallel, are employed and these control a current of one ampere supplied either from a 12-volt battery or from the power mains through a series resistance. The current is switched on by the handle on the right of Fig. 18, when it is desired to speak into the instrument, but no bell, or other calling-up device, is necessary since the received speech is sufficiently loud to attract attention. The microphone is included in the primary circuit of a transformer having four windings in parallel, and the four corresponding secondaries, which are connected in series, supply the speech modulated currents to the line. The receiver is of the reed-controlled diaphragm type, similar in design to the wireless loud speakers described above, but the trumpet, as shown in Fig. 18, is flattened to render the apparatus more compact. Fig. 17 shows a portable hand transmitter, which can be plugged into contact boxes provided at any points in the system from which it may be required to transmit orders or messages. Finally, we may mention that the apparatus, which was primarily designed for use on shipboard, is of particularly strong and simple construction, and is also completely watertight. We understand that it is extensively employed in H.M. Navy.

HARBOUR PLANT.—I.

While it is universally recognised that Britain holds the position of supremacy in shipbuilding, it must not be forgotten that the same ascendancy is shown in the design and construction of special types of vessels as in passenger and cargo ships. Floating cranes, dredgers of the many varied types, and rock breakers are good examples, in which excellence of design, incorporating provisions to meet the most exacting conditions, and sound construction have earned for the British builders a reputation second to none. As sea transport is a vital necessity to our Empire with its component Dominions and Colonies in every part of the world, any development to provide increased trading facilities is important. For ocean-going vessels, deep harbours are essential, and channels must be made and maintained of suitable depth to permit the passage up the rivers to the ports. There are many examples which could be cited, where sea transport is both difficult and costly, because of heavy terminal charges due to the lack of efficient facilities. The provision of effective dredging plant must therefore be regarded as an important step towards improving the trading conditions within the Empire, for by its means navigation may be made possible into the trading centres, where ample and efficient handling gear for the cargo may be installed and the costs entailed may thus be greatly reduced.

The illustrations on Plates XLVI, XLVII and XLVIII and on this page show some examples of the productions of Messrs. Fleming and Ferguson, Limited, of Phœnix Works, Paisley, which are in useful service in various parts of the world and are shown at the Exhibition by means of models.

Fig. 1 annexed and Figs. 2 and 3 on Plate XLVI, represent the latest practice of Messrs. Fleming and Ferguson, Limited, in the design of an 8 cub. yd. dipper dredger. This vessel is suitable for dredging canals, for navigation or drainage, and the cost of the removal of the deposits is much less than with any other type. Other services which it meets admirably are harbour work in confined situations, to depths of not more than 40 ft., dredging old quay walls or foundations and in pile pulling. As it is fixed by vertical spuds, it is entirely independent of anchorage or external moorings, and thus is very suitable for working on waterways where the chains and moorings of an ordinary type of dredger would interrupt the usual navigation. It is not, however, suitable for depositing at great distances, as the range is limited by the length of the boom. It is advisable in all cases to adopt the design to suit the peculiar characteristics of the work, such as the nature of the material to be dealt with, the manner of its disposal and the depth of the water.

A 60-ton floating crane, with many features of interest, is shown in Figs. 4 to 7 on Plate XLVII. The principal dimensions of this vessel are 175 ft. length between perpendiculars, 57 ft. breadth, and 12 ft. 6 in. depth. The propelling machinery consists of two sets of vertical compound engines, with independent condensing plant of sufficient capacity to deal with the exhaust steam from the main engines and auxiliary machinery. Independent air, circulating, feed and bilge pumps are installed. Steam is generated at a pressure of 125 lb. per sq. in., in two marine-type boilers of 14 ft. diameter and 10 ft. 6 in. length. The crane revolves round a forged steel centre post on a ring of live rollers, running between two heavy cast steel paths. The lower one forms a complete ring attached to the deck, which is strongly supported by girders and bulkheads built into the ship. The jib is built up of mild steel sections and plates, and its lower end is carried by two steel pins fitting in bearings at the end of the superstructure. Movement to tilt the jib to various angles is obtained by the use of two forged steel screws with a special form of thread and working through phosphor bronze nuts carried at the end of the jib ties. These screws are turned by an engine driving through spur and bevel gearing. All the motions of main hoisting, auxiliary hoisting, derricking, slewing and ballast racking are operated by steam power. When working with a load of 60 tons the maximum radius is 80 ft. and the height of lift obtainable is 90 ft. For a load of 20 tons a radius of 90 ft. may be worked at. Sufficient drift is provided for a range of lift of from 20 ft. below sea level. The speed of hoisting with the main lift is 10 ft. per minute and with the auxiliary load three times that value. In slewing operations with the full load of 60 tons on the crane, a complete revolution can be performed in three minutes, while the full derricking range with the same load can be effected in ten minutes. To keep the angle of heel of the pontoon as restricted as possible, travelling ballast is mounted on two carriages, which are arranged to run on the outside longitudinal girders of the superstructure. All the crane-operating levers are placed in a cabin from which the operator has an uninterrupted view of the load. When the vessel carries the full load of 60 tons, and is fully supplied with coal, water and stores, a speed of 10¾ knots can be maintained. Steam-reversing gear of the direct-acting type with a hydraulic control cylinder is fitted to the propelling engines.

The construction of a pontoon fitted with equipment for rock breaking below the water, which is also a product of Messrs. Fleming and Ferguson, Limited, is illustrated in Figs. 8 to 13 on Plate XLVII. This is representative of the firm's latest design, and the bolster block or chisel guide can be raised and lowered to suit the varying depth of water overlying the rock bottom, enabling a standard length of steel chisel to be used for all depths. A rock cutter of this design is capable of breaking up to 100 cub. yd. of rock per day without the use of any type of explosive and for a consumption of about 1 ton of coal. The rock is broken by raising the chisel or ram 5 ft. to 10 ft. above the rock surface, the height being adjusted to meet the conditions of hardness of the material, and is then released. The chisel has a weight of from 10 tons to 20 tons, and its end is fitted with a hard steel point to facilitate entry into the material at impact. Repeated operations break up the rock, which can then be lifted by a bucket or grab dredger. The average number of blows delivered per hour is from 130 to 150, sufficient to release 10 cub. yd. of rock each working hour. The whole of the operations of this economical plant can be conducted by a crew of only four men.

Good examples of dredging craft are shown in Figs. 14 to 17 on Plate XLVIII. The first of this series, Fig. 14, represents the Paritutu, a twin-screw vessel equipped as a combined bucket and suction pump hopper dredger. The capacity of the hopper is 400 tons. The buckets lift 300 tons in an hour from a depth of 40 ft. below the light water line and the pumps will raise 800 tons per hour from the same depth. The vessel has a speed of 8 knots. Fig. 15 shows the Sir William Matthews, a sea-going hopper dredger, which is representative of the latest practice in this type. The design is eminently suitable for a vessel which requires to discharge the dredgings from the hopper at sea in rough weather. The fore end is similar in design to the peak of an ordinary sea-going vessel, and the boat can weather a rough sea better than the older design of bow well dredger. The hopper capacity is 1,200 tons, and the dredger can remove 900 tons per hour from a depth of 45 ft. below water level, and carry it out to sea at a speed of 10 knots.

The Kaione, illustrated in Figs. 16 and 17, is a stern well hopper dredger of the Fruhling type, designed to work both as a drag suction and a cutter suction type. When at work as a drag suction plant a broad suction head is fitted to the end of the cutter, which carries the suction pipe, and on this being lowered to the bottom of the river the vessel is driven slowly ahead by means of the propelling engines. The material raised by the suction pump is usually discharged into the hopper of the vessel, but it can be delivered into hopper barges alongside if desired. Doors are provided at the bottom of the hopper for the discharge of the dredgings at sea, but the material may be used for reclamation purposes, by the use of sand pump drawing from the hoppers and delivering ashore through a floating pipe line. To deal with clay or hard compact material, the suction head is removed and a special rotary cutter fitted at the bottom end of the suction

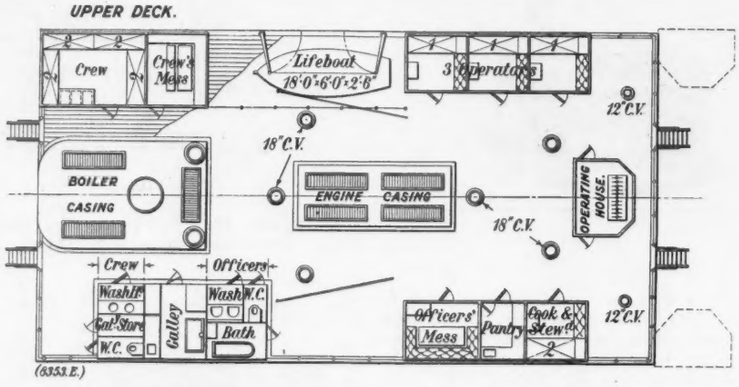


FIG. 1. UPPER DECK OF DRIFTER DREDGER; MESSRS. FLEMING AND FERGUSON, LIMITED, PAISLEY.

THE BRITISH EMPIRE EXHIBITION; BEARDMORE-TOSI OIL ENGINE.

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS, DALMUIR.

(*For Description, see Page* 530.)

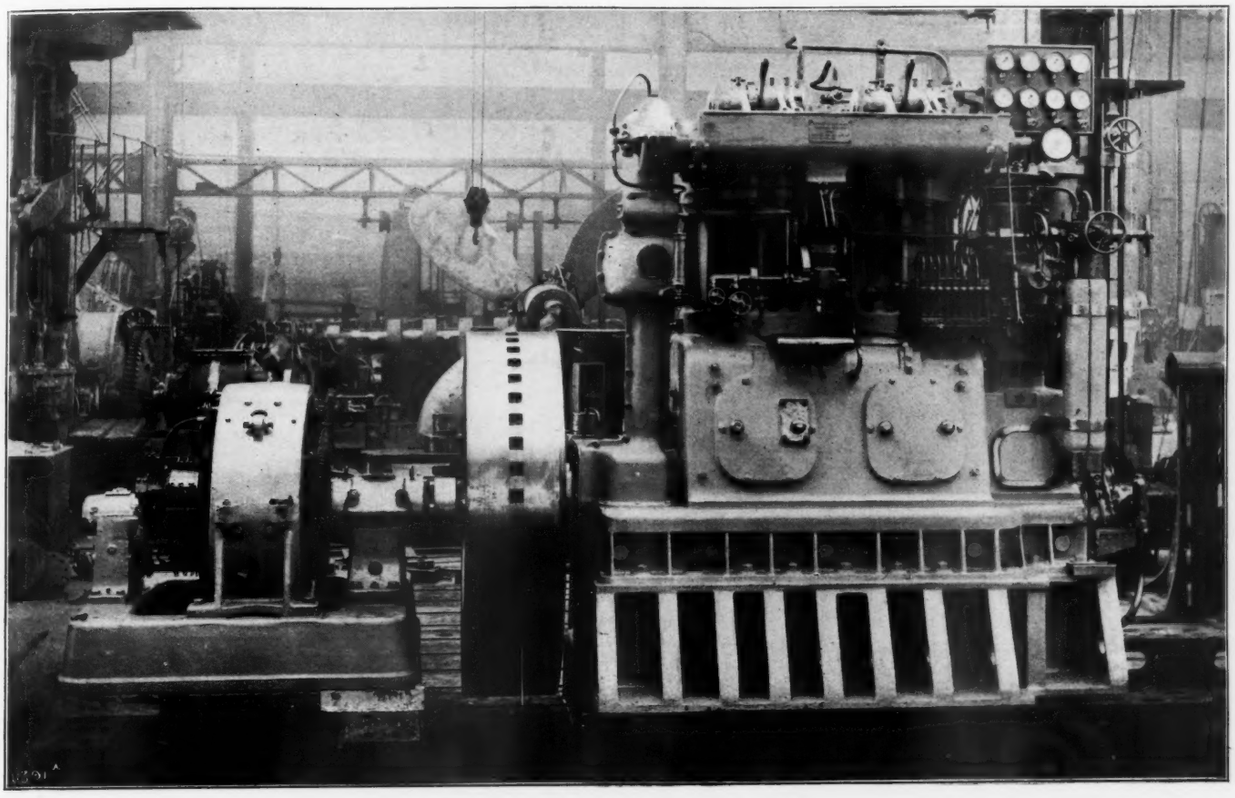


FIG. 3. FRONT VIEW OF 130 H.P. ENGINE AND GENERATOR.

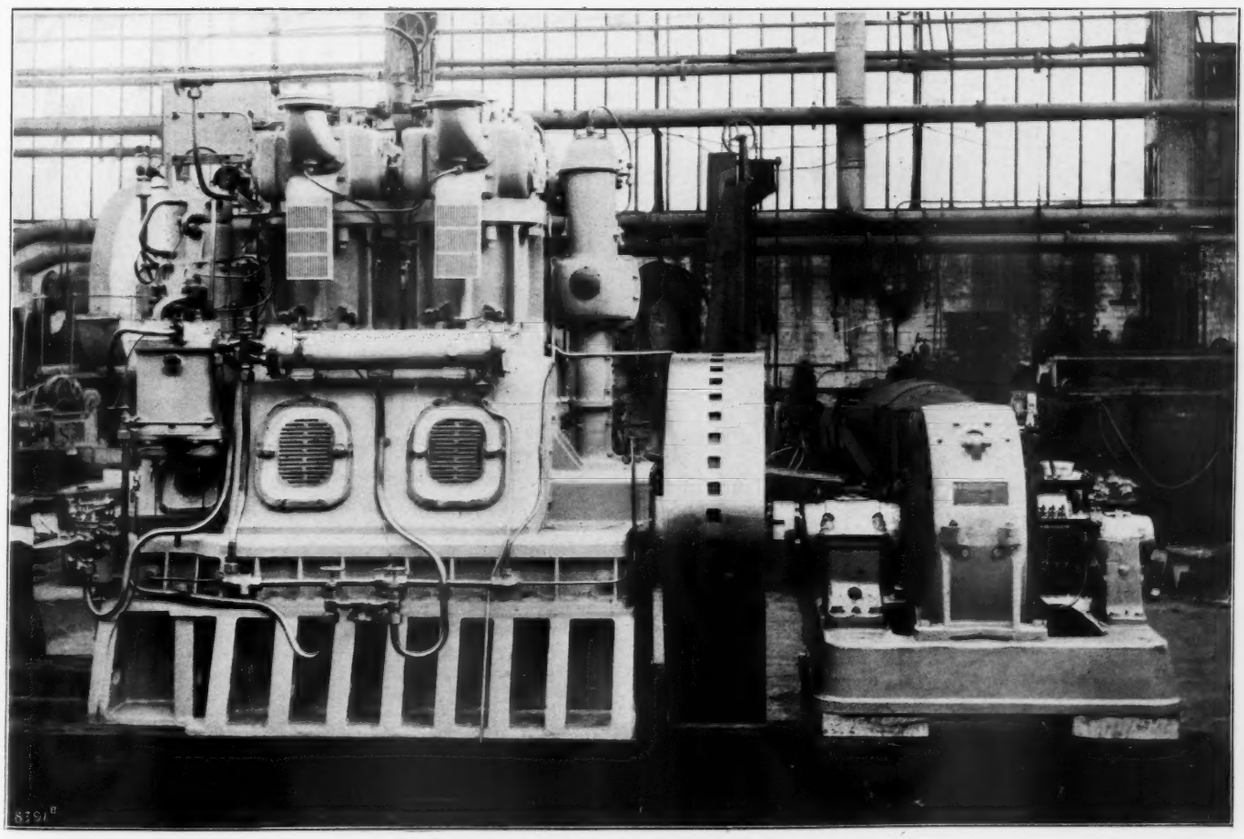


FIG. 4. BACK VIEW OF 130 H.P. ENGINE AND GENERATOR.

(*To face page* 530.)

BRITISH EMPIRE EXHIBITION; INTERNAL COMBUSTION ENGINES.

CONSTRUCTED BY MESSRS. W. H. ALLEN, SONS AND CO., LIMITED, ENGINEERS, BEDFORD.

(*For Description, see Page* 530.)

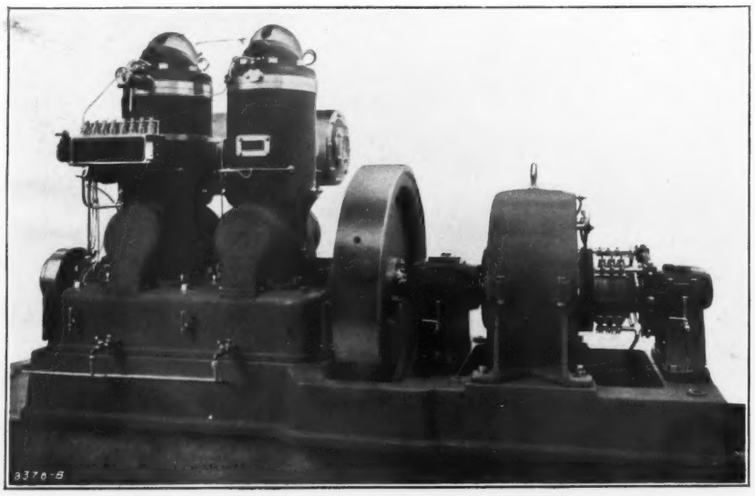


Fig. 5. 36-Kw. Marine Auxiliary Set.

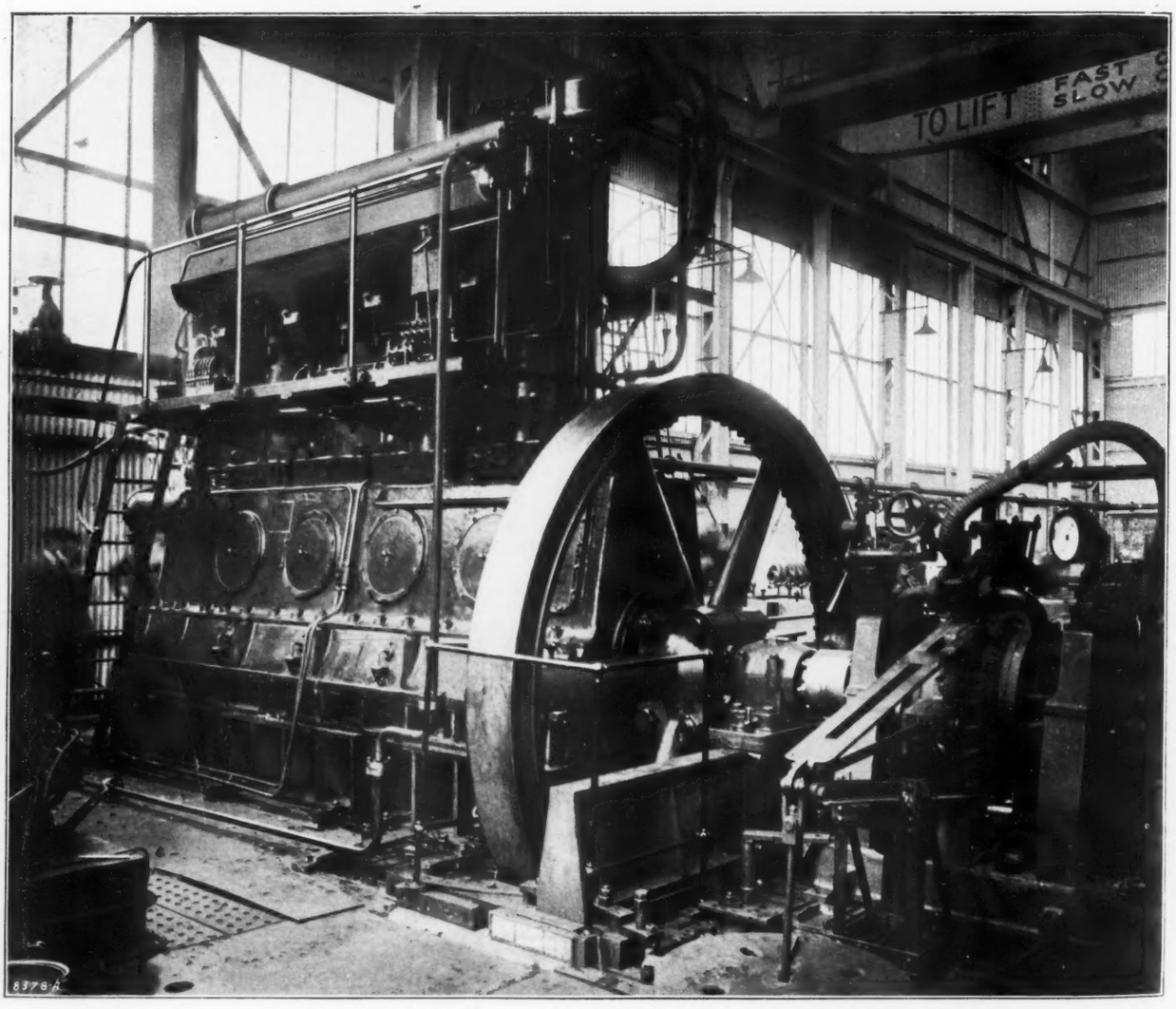


Fig. 6. 320 B.H.P. Four-Cycle Diesel Engine (Burmeister and Wain Type).

(*To face page* 531.)

THE BRITISH EMPIRE EXHIBITION; DIPPER DREDGER.

CONSTRUCTED BY MESSRS. FLEMING AND FERGUSON, LIMITED, ENGINEERS AND SHIPBUILDERS, PAISLEY.

(*For Description, see Page 546.*)

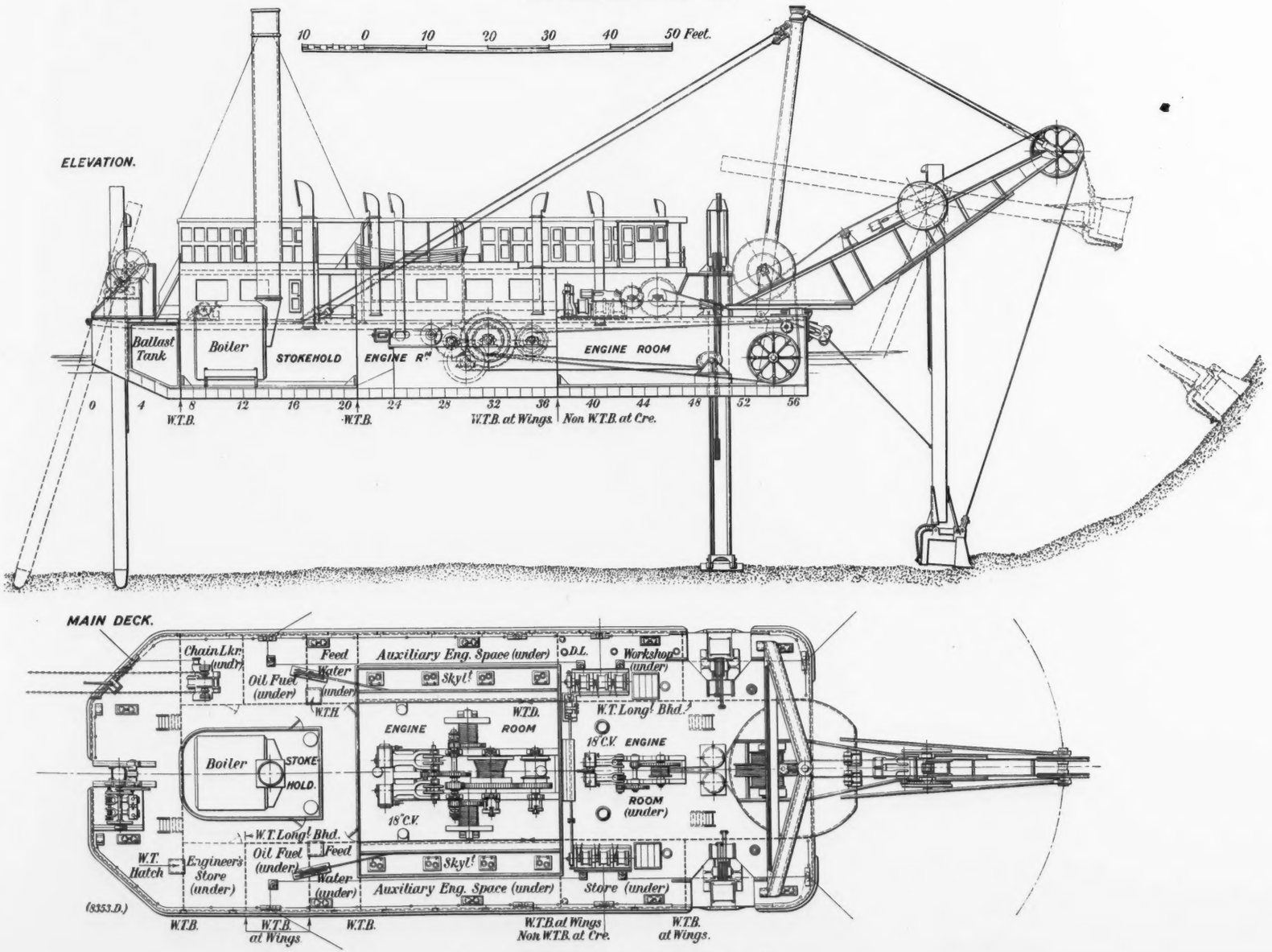


FIG. 2 AND FIG. 3. 8-CUBIC YARD DIPPER DREDGER.

(To face page 546.)

THE BRITISH EMPIRE EXHIBITION; FLOATING CRANE AND ROCKBREAKER.

CONSTRUCTED BY MESSRS. FLEMING AND FERGUSON, LIMITED, ENGINEERS AND SHIPBUILDERS, PAISLEY.

(For Description, see Page 546.)

Fig. 6. OFFICERS' AND BOAT DECK

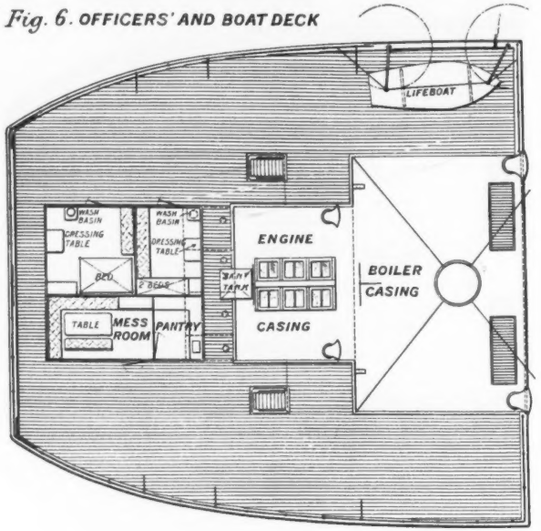
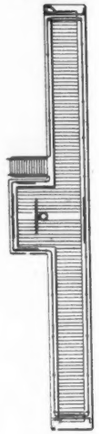


Fig. 7

BRIDGE.



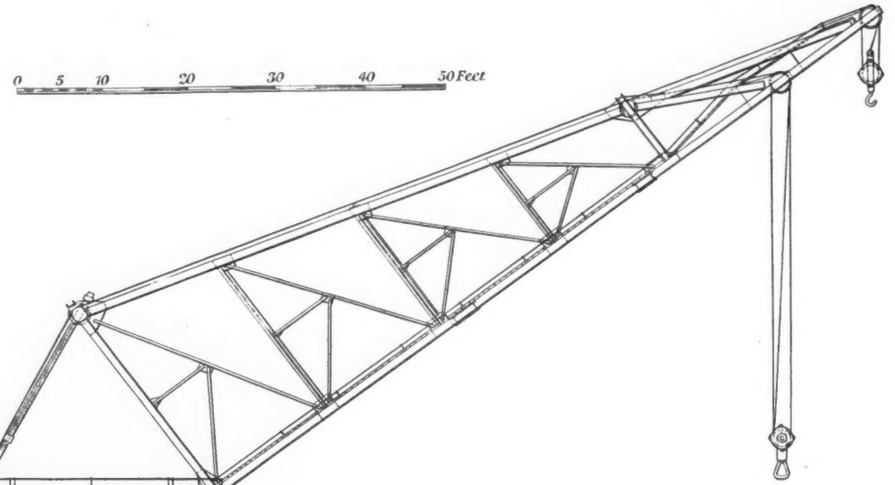


Fig. 4.

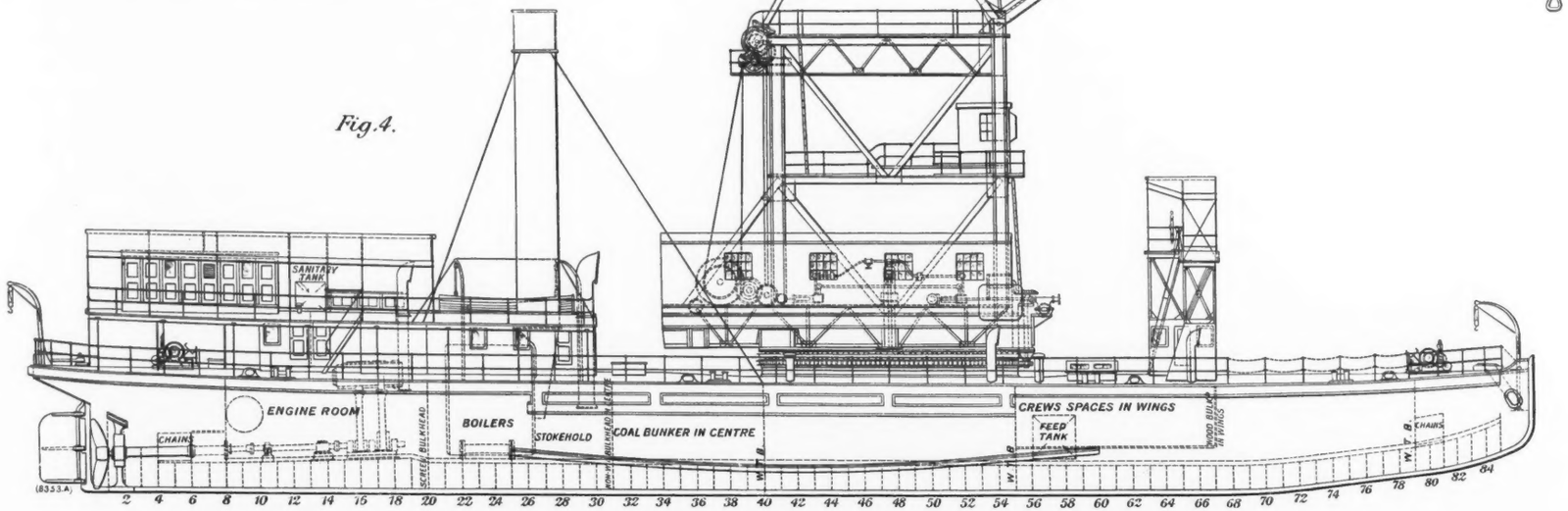
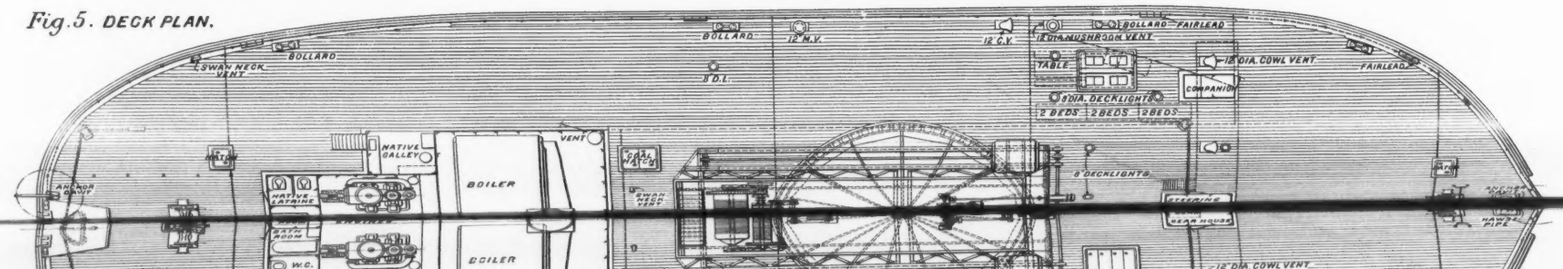
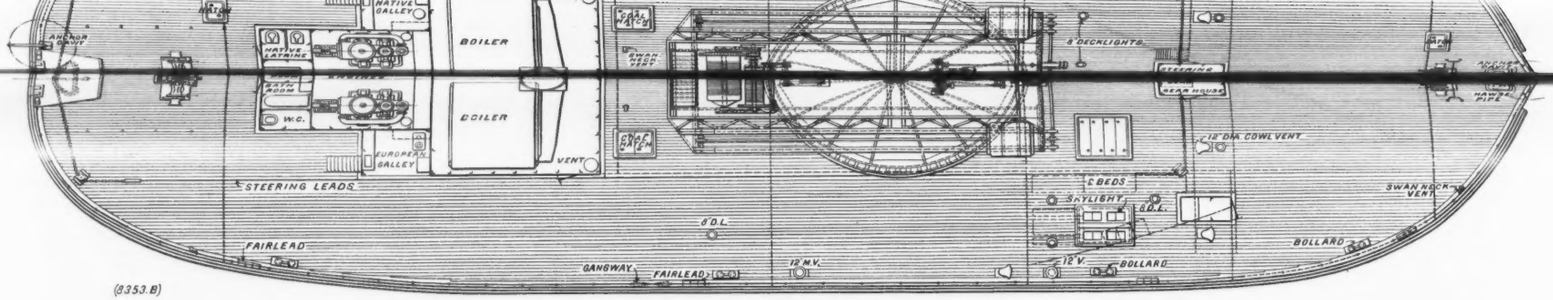

SANITARY TANK
ENGINE ROOM
CHAIN
SCREEN BULKHEAD
BOILERS
STOKEHOLD
COAL BUNKER IN CENTRE
CREWS SPACES IN WINGS
KEEP TANK
CHAINS
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80 82 84

Fig. 5. DECK PLAN.





FIGS. 4 TO 7. 60-TON FLOATING CRANE.

Fig. 11.

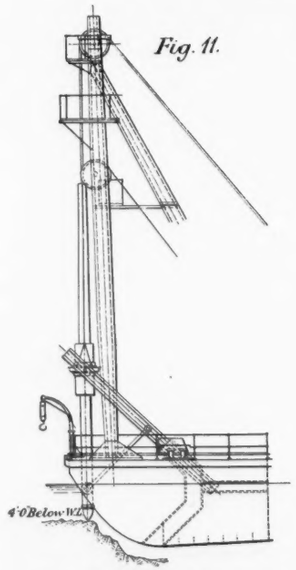


Fig. 8.

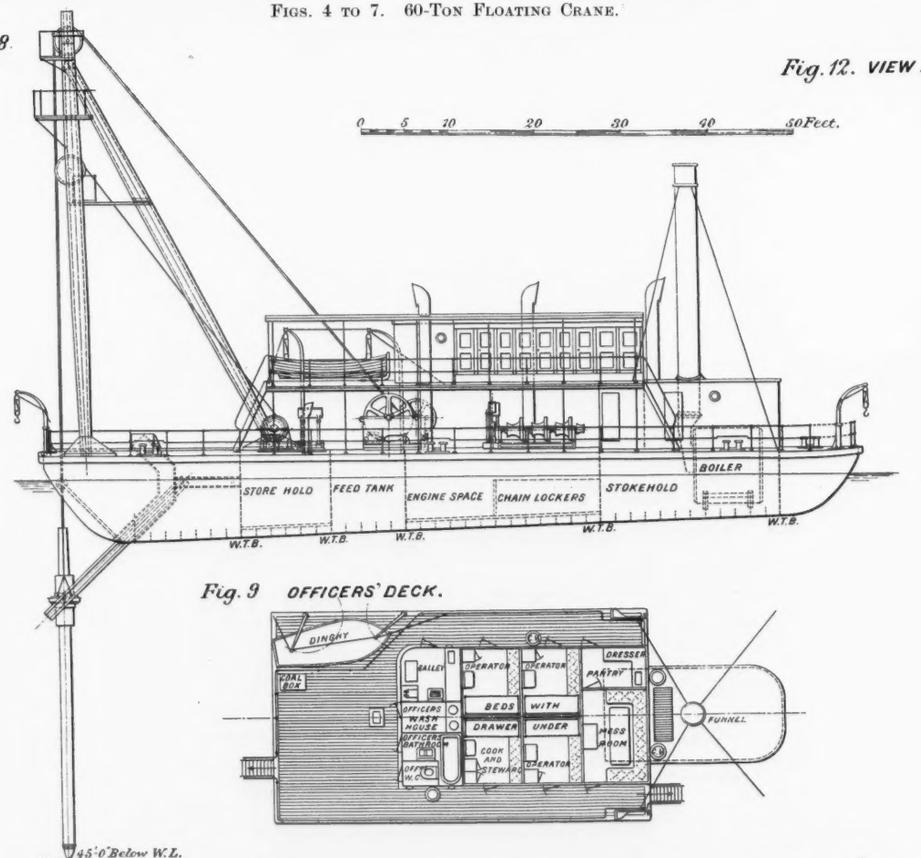


Fig. 12. VIEW AT STERN.

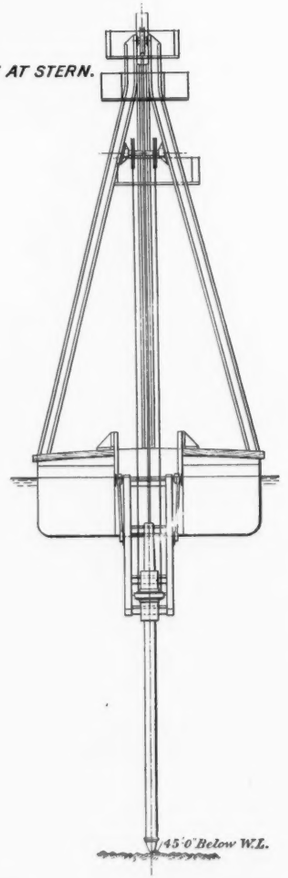


Fig. 13. ENGINE SPACE.

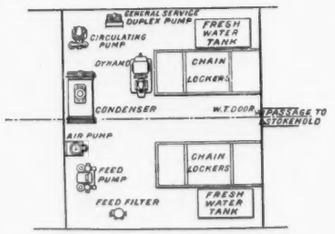
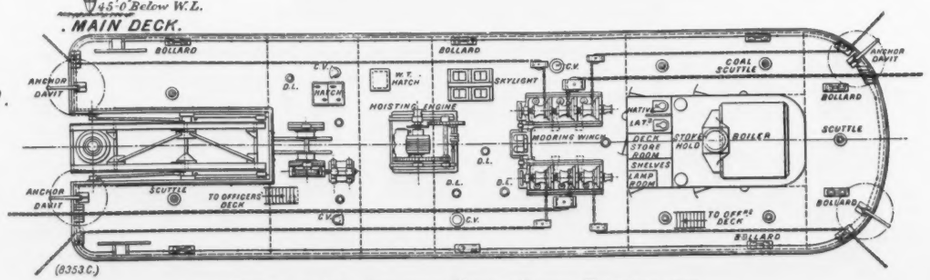


Fig. 9 OFFICERS' DECK.

Fig. 10.



FIGS. 8 TO 13. PONTOON UNDER-WATER ROCKBREAKER.

THE BRITISH EMPIRE EXHIBITION; DREDGING PLANT.

CONSTRUCTED BY MESSRS. FLEMING AND FERGUSON, LIMITED, ENGINEERS AND SHIPBUILDERS, PAISLEY.

(*For Description, see Page* 546.)

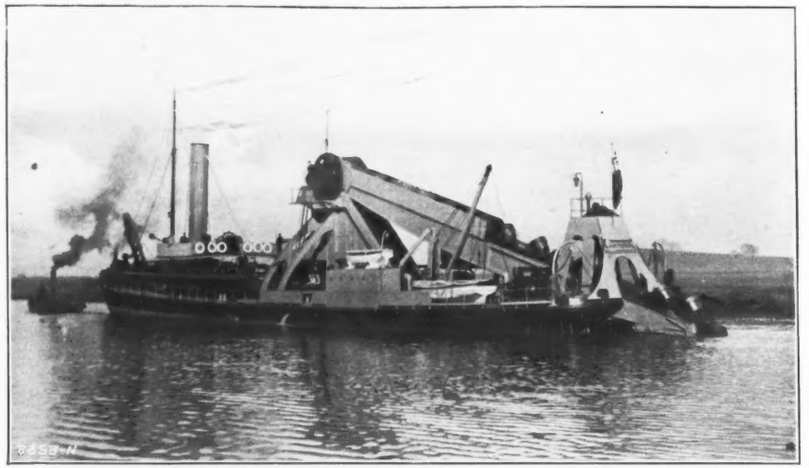


FIG. 14. BUCKET AND SUCTION HOPPER DREDGER "PARITUTU."

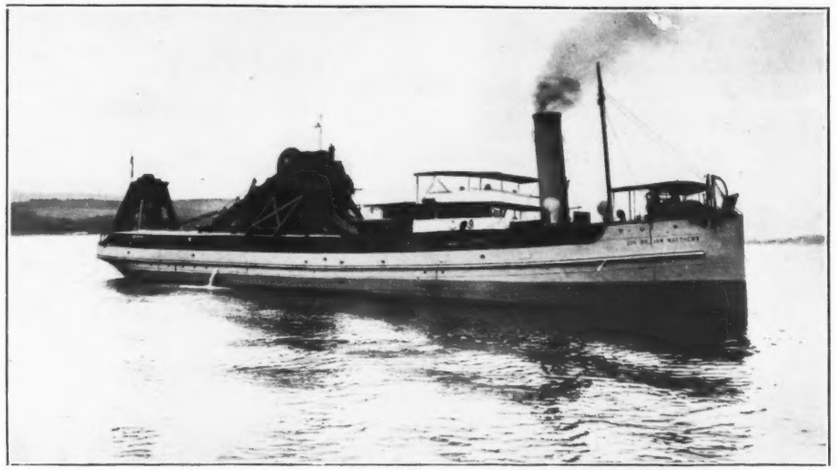


FIG. 15. STERN WELL BUCKET HOPPER DREDGER "SIR WILLIAM MATTHEWS."

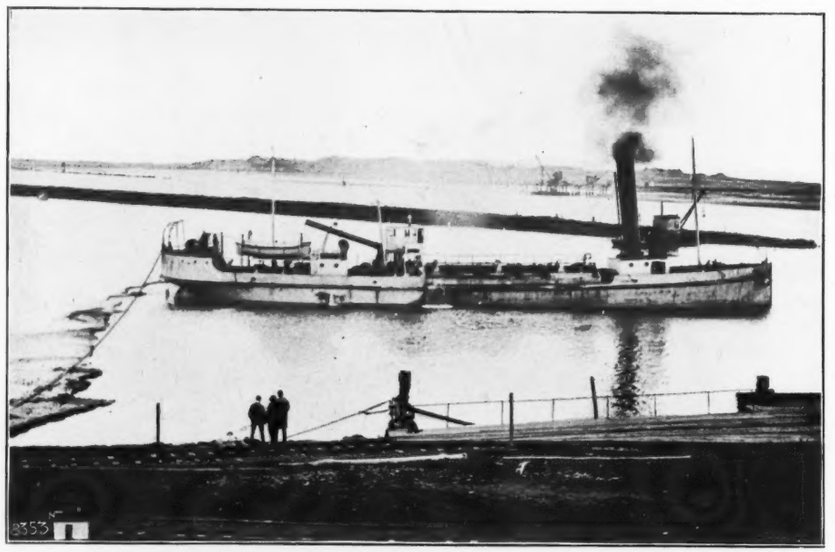


FIG. 16. SUCTION HOPPER DREDGER "KAIONE."

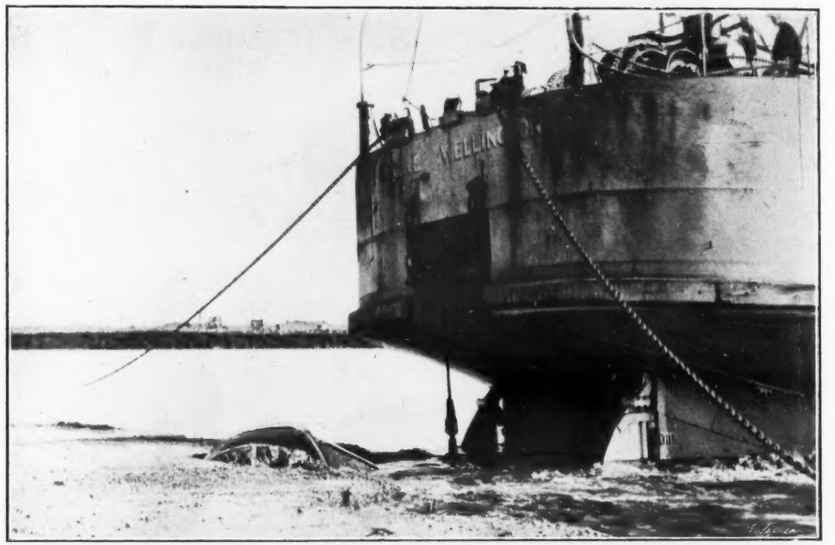


FIG. 17. THE "KAIONE" AT WORK.

THE BRITISH EMPIRE EXHIBITION: DREDGING PLANT.

CONSTRUCTED BY MESSRS. LOBNITZ AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, RENFREW.

(*For Description, see Page* 547.)

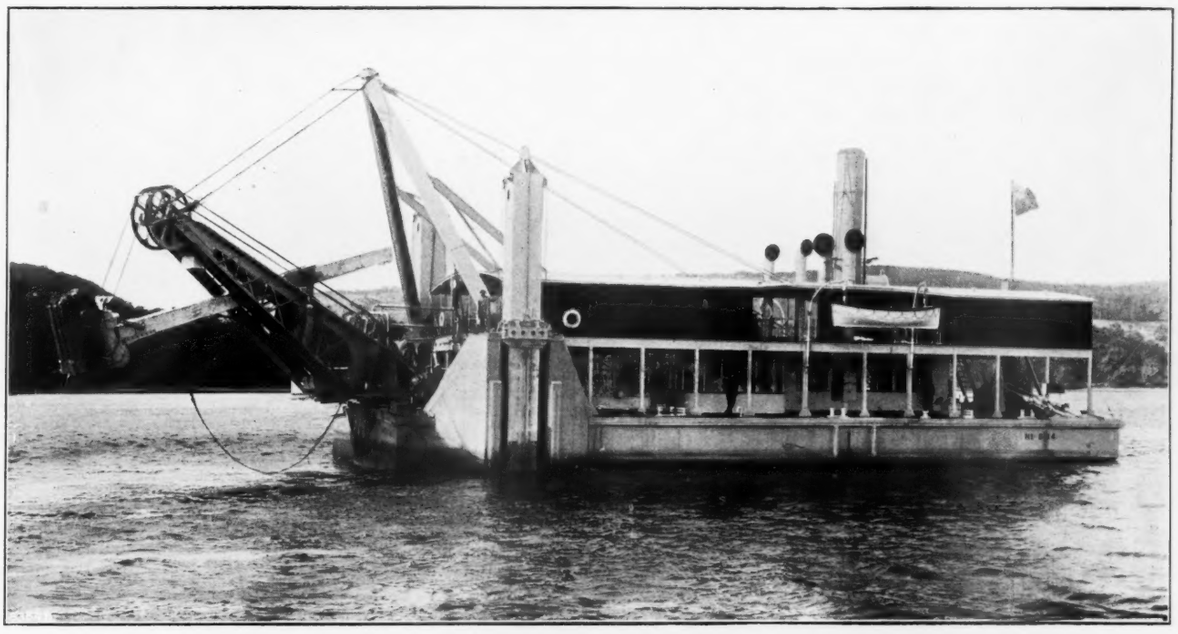


Fig. 18. Dipper Dredger "Lucayan."

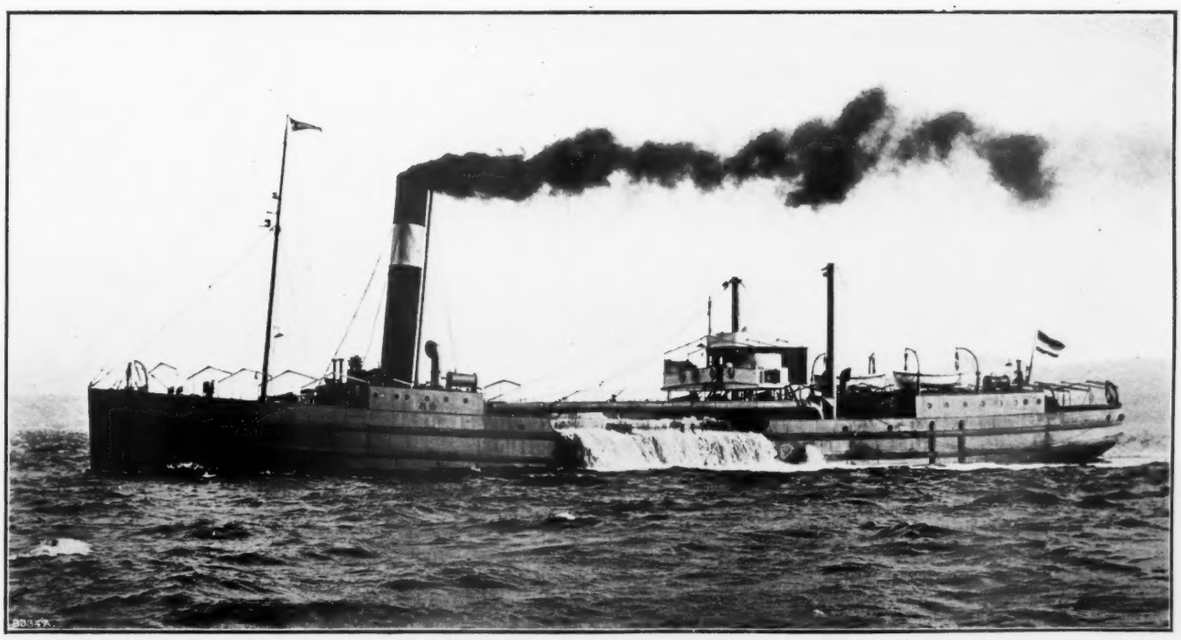


Fig. 19. Suction Hopper Dredger "K'uai Li."

(*To face Plate XLVIII.*)

THE BRITISH EMPIRE EXHIBITION; THE CUTTER SUCTION DREDGER "RONALDSHAY."

CONSTRUCTED BY MESSRS. WM. SIMONS & CO., LIMITED, ENGINEERS AND SHIPBUILDERS, RENFREW.

(*For Description, see Page* 548.)

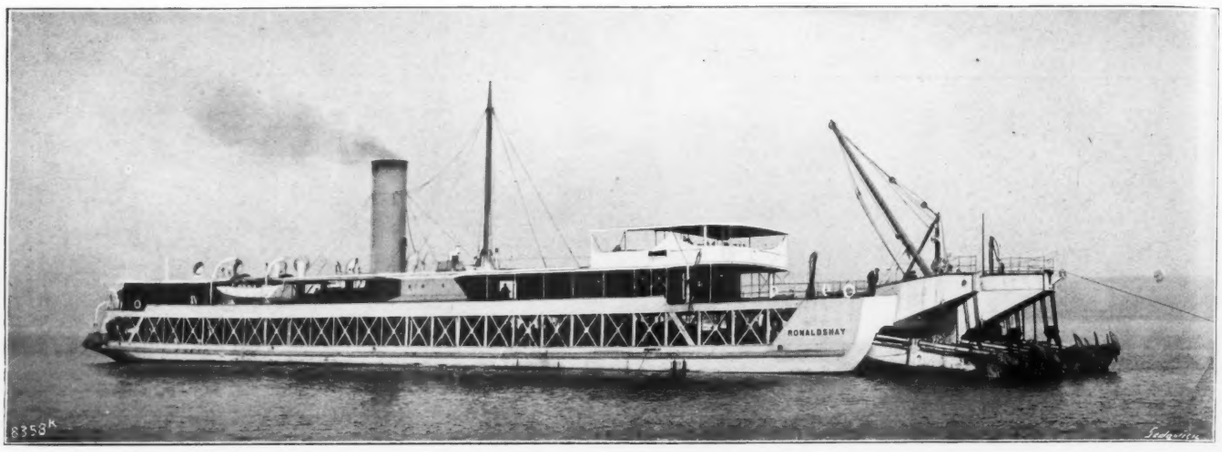


Fig. 20. General View.

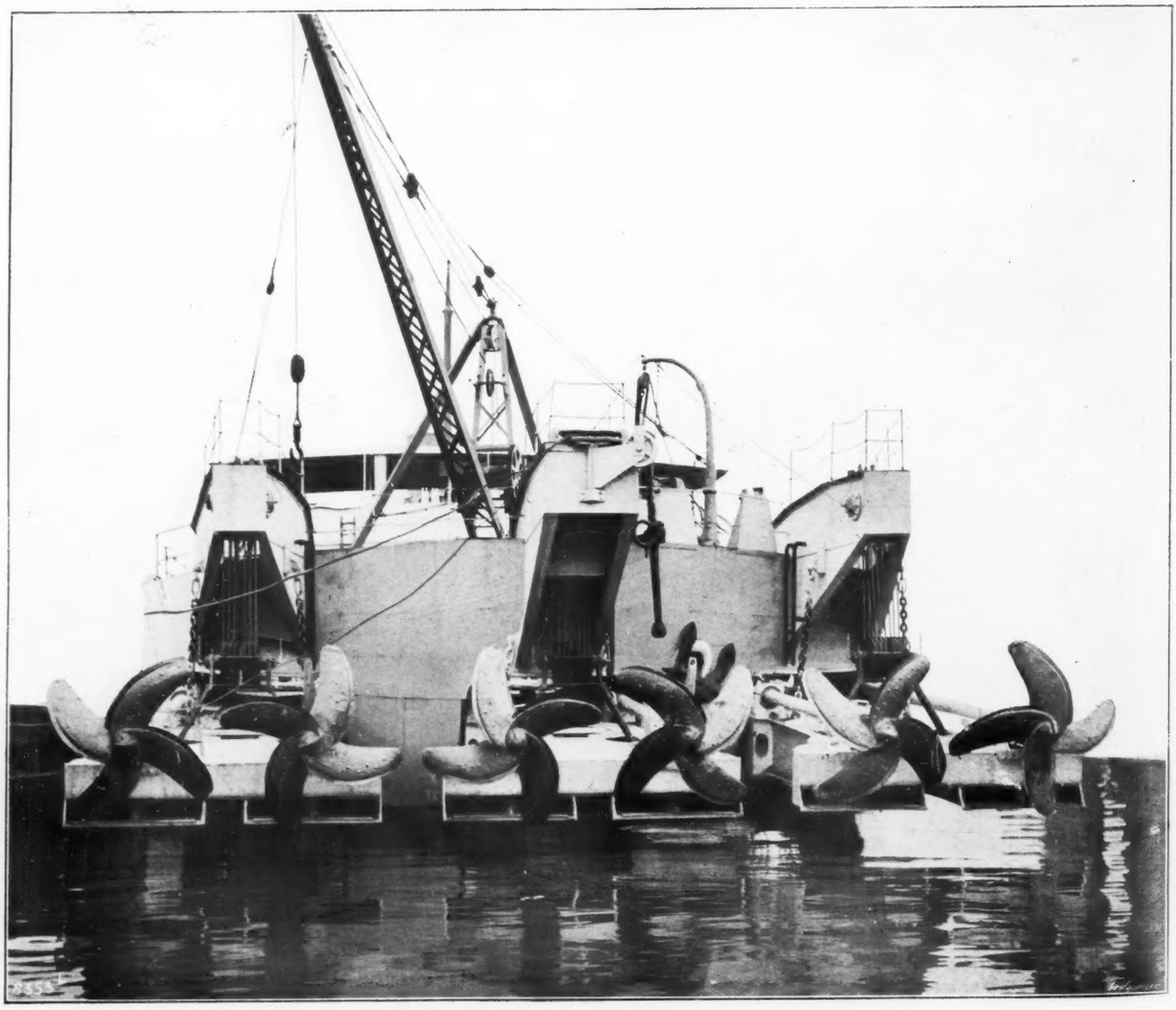


Fig. 21. Bow View Showing Cutters and Suction Pipes.

(*To face page* 547.)

THE BRITISH EMPIRE EXHIBITION; DREDGING PLANT.

CONSTRUCTED BY MESSRS. WM. SIMONS AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, RENFREW.

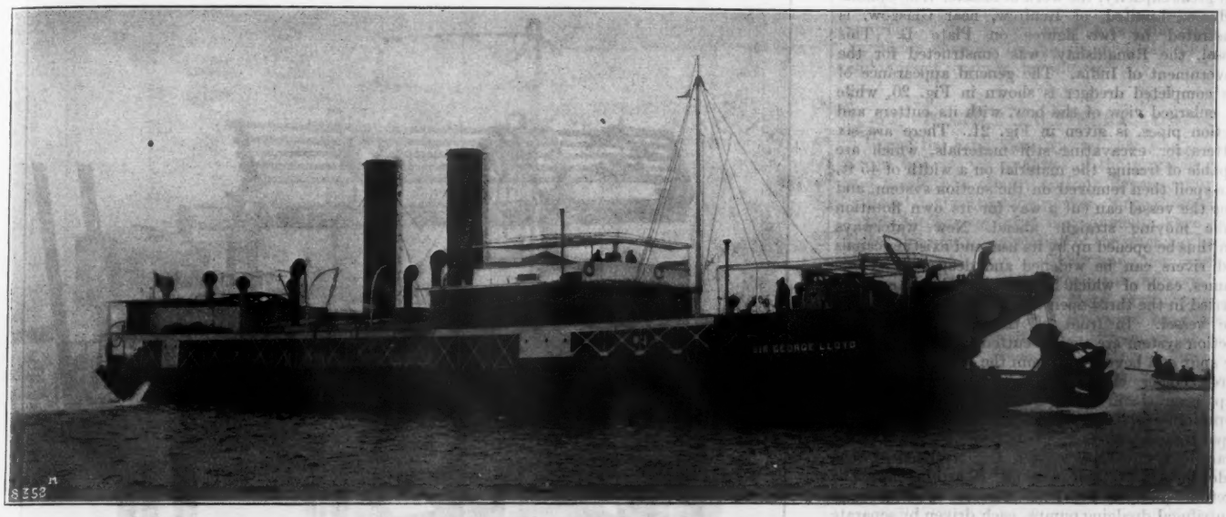


Fig. 22. Cutter Suction Dredger Constructed for Bombay Reclamation Scheme.

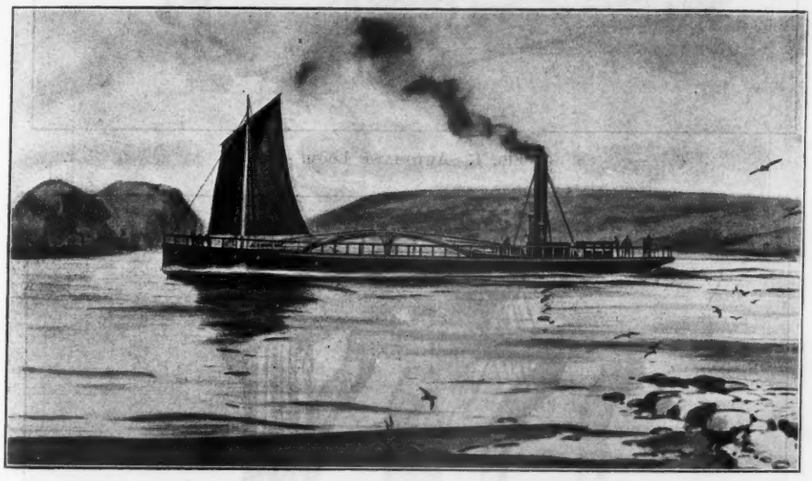


Fig. 23. First Steam Hopper Barge.

pipe. An independent engine is provided for the driving of this cutter through gearing and shafting led down the ladder.

Two examples of the work of Messrs. Lobnitz & Co., Limited, of Renfrew, are illustrated on Plate XLIX in Figs. 18 and 19. Of these, the former is the Lucayan, a dipper dredger built for the Government of the Bahamas. The hull is 110 ft. in length, 44 ft. in breadth and 12 ft. in depth, as small a size as is practicable for handy working, but of sufficient beam to give ample stability when the boom is swung to one side. It works on two main spuds forward and a third at the stern. When dredging, part of the weight of the vessel is taken by these main spuds which hold her in position and make her independent of swells and currents. As the spuds hold the dredger in position mooring chains or wire ropes are not necessary and thus the Lucayan can be used successfully on a canal where there may be passing vessels or in a confined corner of a harbour. The main spuds are of steel 4 ft. by 4 ft. in section, and each weighs 30 tons. This dredger can be moved by its own power by raising the spuds and pulling or pushing with the dipper bucket on the ground, or it can be revolved upon one spud as a centre. It can also be used to cut a way for its own flotation.

The digging power of this type of equipment, as applied at the actual cutting edge, is very greatly in excess of what is possible with a ladder dredger of equal capacity. The dipper arm is of solid laminated construction composed of wood and steel which, while it permits reduction of weight to quite a large extent, gives all the strength that is required for the heavy service to which it is put. The dipper arm is sufficiently flexible to yield slightly to any sudden application of stress to the bucket. Dredging is possible with the Lucayan to a depth of 40 ft. and the bucket can be swung in working through an angle of 180 deg. A complete cycle of operations can be performed in 40 seconds, and the bucket is of such capacity that 480 cubic yards of material can be removed in an hour, which corresponds in weight to about 650 tons. In place of the common rack and pinion gear, the dipper arm is actuated by wire ropes from the boom engine. Flexibility is thus introduced into the working, while replacement is easy of accomplishment and the wear and tear is greatly reduced. All the brakes in this equipment are worked by compressed air instead of steam. There is no separate bail on the dipper, but in place of that construction it is cast on solid, and thus contributes to the strength of the dipper and leaves the whole top open for boulders.

The main engines are of the slow running vertica type provided with direct duplex parallel hoisting wires and extra large sheaves. High speed of working is thus obtained without heavy wear and tear of the ropes. The swinging engine and turntable are at the main deck level which permits the operator's stand to be on the bridge overhead, from which position he can command a full view of all work and also see the machinery. In this position one man can control all movements of the dredger. The control of the feed and the dumping of the dipper provides work for another man. The Lucayan is equipped with a 6-drum winch for handling the barges on each side of the ship. Fairleads are provided, so that barges of 1,000 cub. yards capacity can be controlled and moved along by a single man. Auxiliary tackle is provided on the boom so that large rocks and boulders can be lifted off the dipper when they are brought up. An auxiliary use of the dredger is possible when the dipper is unshipped, for in that condition it can render useful service as a 60-ton floating crane. Accommodation is provided in teak deckhouses on the upper deck for three operators and there are other cabins for the cook and steward and a crew of seven.

A trailing suction hopper dredger, also constructed by Messrs. Lobnitz and Co., Limited, is shown in Fig. 19. This was built for the Hai-Ho Conservancy Commission for service on the Taku Bar. The name chosen for this vessel was K'uai Li, which in Chinese has the significant meaning, the fast and powerful one. She is a vessel with a hull of 250 ft. length, 42 ft. breadth and 16 ft. depth and travels at 11 knots. She is propelled by twin screws and has compound surface condensing engines totalling 1,500 i.h.p. The steam generating plant consists of two single-ended boilers of 14 ft. 10 in. diameter and 11 ft. length and a vertical donkey boiler of 6 ft. diameter by 12 ft. 6 in. The vessel dredges the Taku Bar by steaming over it, without moorings or anchorage of any kind. A special mouthpiece is fitted at the end of the suction pipe which resembles a plough and the pumping plant, which is entirely independent of operation from the main engines, is so effective that a vacuum of 25 in. is established in the suction pipe and has actually been maintained while dredging and discharging thick clay. The clay discharged is deposited directly in the hopper which is of bottle-neck shape and can hold 20,000 cub. ft. of material or about 1,000 tons weight. The dredgings come out of the discharge pipe of the pump in a thick sticky mass not diluted with a large quantity of

water. In service the K'uai Li has done credit to her name by decreasing the bar, it works upon about 8 ft. over a channel of 200 yards width in about six months.

A very remarkable dredger of interesting design and great capacity, the work of Messrs. Wm. Simons and Co., Limited, of Renfrew, near Glasgow, is illustrated by two figures on Plate L. This vessel, the Ronaldshay, was constructed for the Government of India. The general appearance of the completed dredger is shown in Fig. 20, while an enlarged view of the bow, with its cutters and suction pipes, is given in Fig. 21. There are six cutters for excavating stiff materials, which are capable of freeing the material on a width of 45 ft. The spoil then removed on the suction system, and thus the vessel can cut a way for its own flotation while moving straight ahead. New waterways can thus be opened up by its use, and existing canals and rivers can be widened and deepened. Three frames, each of which has two suction orifices, are carried in the three open wells at the forward end of the vessel. In front of these openings to the suction system are the six cutters, which are driven by spur and bevel gears from the crankshafts of the three cutter engines, which are all compound expansion steam sets. Dredging is possible to a depth of 30 ft. below the water level, and the suction pipe frames are each controlled by steam hoist gears and wire rope tackles, and arranged so that independent or joint working is attainable. The suction pumping system consists of two main centrifugal dredging pumps, each driven by separate vertical triple expansion engines. The dredged material taken from the suction pipes is discharged direct from a floating pipe line, 600 ft. length, to a terminal pontoon, where the pipe is raised to a height of 25 ft. above the water level and carried over the river bank to a distance of 150 ft. from the floating pipe line and at right angles to it. The floating discharge pipe line is in 50 ft. lengths, coupled together by steel ball and socket joints and carried on circular pontoons. Water-tube boilers are installed to supply the steam for the engines while a refrigerating plant and electric generator for lighting are among the items of equipment of this interesting dredging vessel. At the official trials the Ronaldshay made a cut approximately 300 ft. length, 40 ft. width and 10¾ ft. depth in 40 minutes, and actually a total of 5,354 cubic yards was dredged in this time, which corresponds to removing 10,000 tons of material per hour.

Another vessel of which a model is shown at the exhibition is the Sir George Lloyd, illustrated in Fig. 22. This dredger is of the cutter suction-pump reclamation type, and was built for work at Bombay in connection with the Back Bay Reclamation Scheme, which is being carried out under the direction of Sir George Buchanan. The dredger is fitted with a powerful pumping plant, designed to dredge 2,000 cubic yards of clay per hour from depths of as much as 70 ft., and discharge the material through a floating pipe line to a distance of 5,000 ft. from the dredger. On some sections of its work, the distance to the place of discharge is 10,000 ft., and for these cases the builders, Messrs. Wm. Simons and Co., Limited, have constructed a floating pumping station, arranged for coupling to the floating pipe line and provided with plant capable of discharging to a distance of 5,000 ft. and to a height 16 ft. above water level. Two sets of compound surface condensing engines are used for the propulsion of the dredger, while the large centrifugal suction and discharge pump is driven by a triple expansion steam set and a compound engine drives the spiral cutter on the lower end of the suction frame. In contrast with these great modern outfits for dredging Messrs. Wm. Simons and Co., Limited, show a model of the first steam hopper barge ever, built in this country. This is illustrated in Fig. 23 and was the first of four built in the year 1862 for the Clyde Navigation Trustees. The vessel has a hopper capacity of 300 tons and is fitted with 12 hopper doors, controlled by hydraulic gear. The actual dimensions are 133 ft. length, 23 ft. breadth and 10 ft. 6 in. depth, while the mean draft when loaded is 8 ft. The propulsion machinery consists of a two-cylinder jet condensing engine, for which steam is supplied by a cylindrical multitubular boiler.

THE BRITISH EMPIRE EXHIBITION: LOOMS.

CONSTRUCTED BY MESSRS. ROBERT HALL AND SONS, BURY, LIMITED, ENGINEERS, BURY.

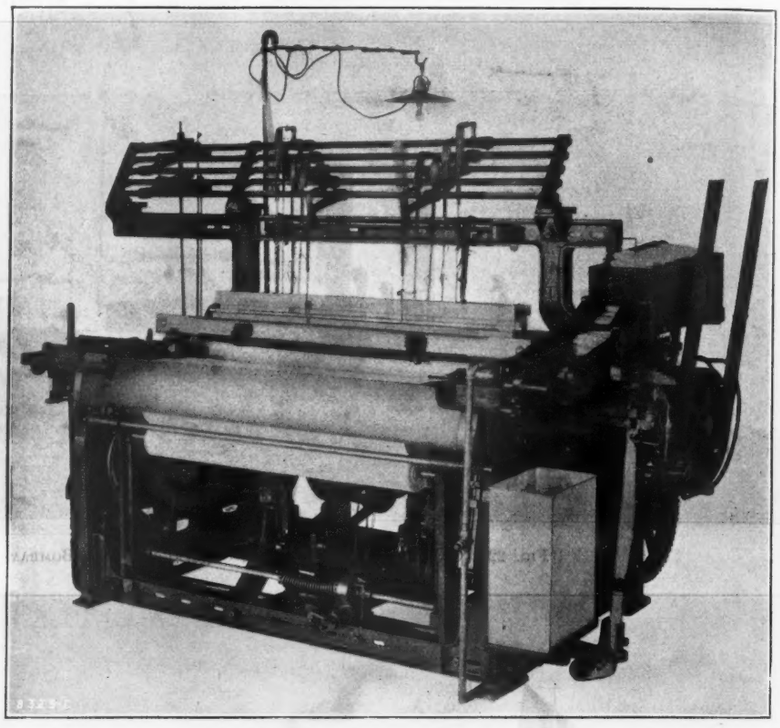


FIG. 1. AUTOMATIC LOOM.

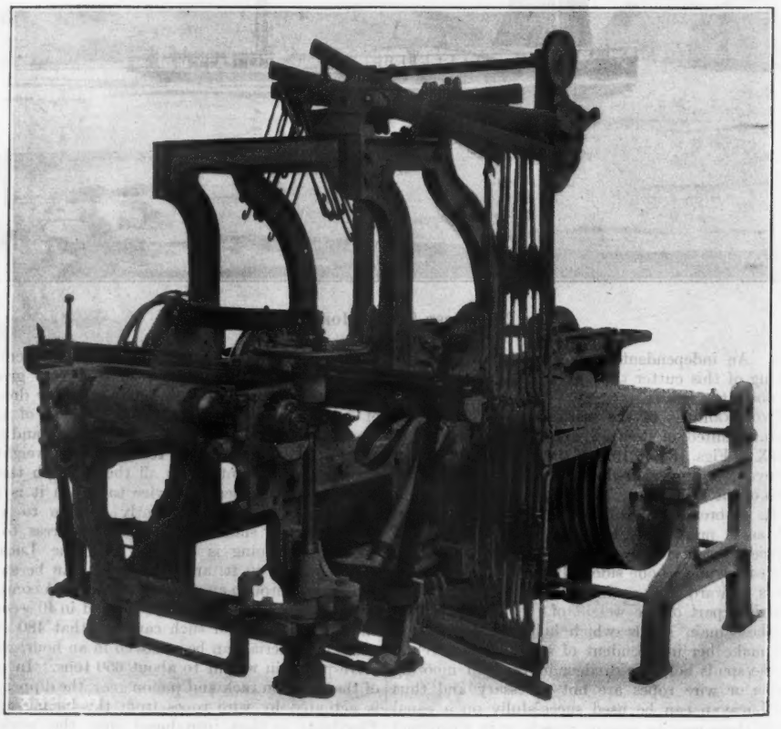


FIG. 2. LOOM FOR BELT MAKING.

Captain Fryatt's historic vessel, the ss. Brussels, after being torpedoed by the Germans and having bombs exploded in her machinery spaces till she sank at Zeebrugge, was raised and made seaworthy again by the firm of Henry Robb, Limited, of Edinburgh Docks, Leith. This concern, in addition to its work in ship repairing, constructs dredgers of various types, and models showing examples of its designs are to be seen on its stand in the Palace of Engineering. A feature of special interest is the

BRITISH EMPIRE EXHIBITION; TEXTILE MACHINES.

CONSTRUCTED BY MESSRS. ROBERT HALL AND SONS, BURY, LIMITED, ENGINEERS, BURY.

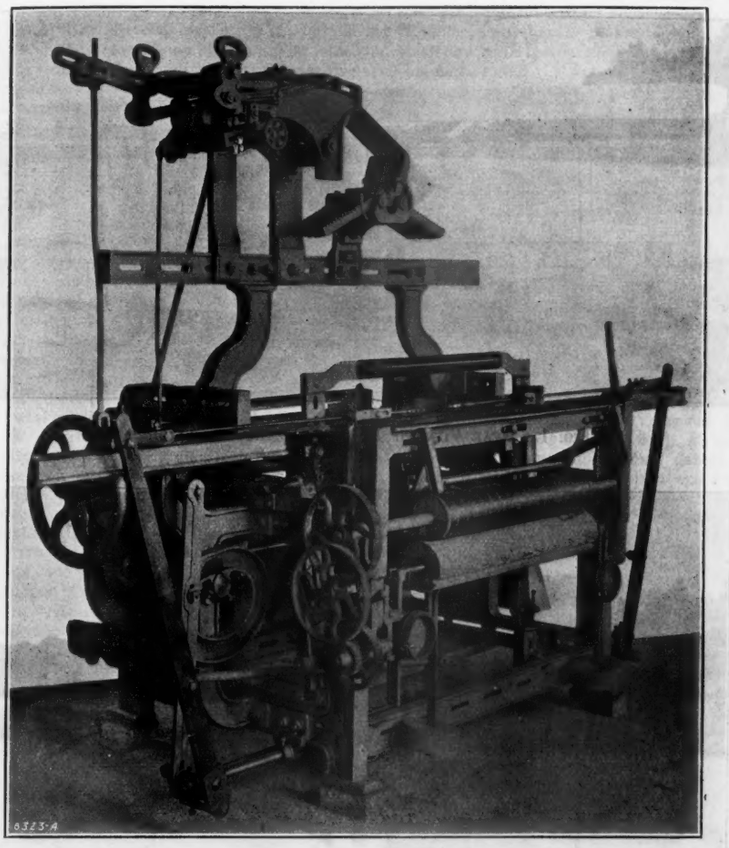


Fig. 3. Loom for Making Horsehair Cloth.

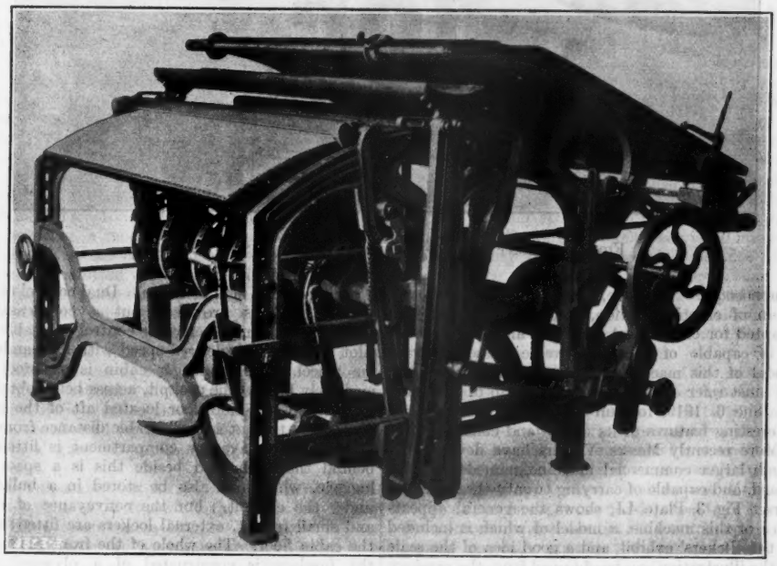


Fig. 4. Cloth Folding and Measuring Machine.

self-dumping barge which they have designed. This was introduced to compete with the present type of hopper barge which is expensive to maintain. The new type has no elaborate mechanical appliances; the only equipment fitted is simple and consists of two flooding valves. This barge is constructed with a double hold or hopper, having at each side a buoyancy space. On one side the buoyancy space is sub-divided into two watertight chambers, each of which has a flooding valve and air pipe. When the barge has been loaded it is towed to the dumping ground, the flooding valve is then opened by a lever and cord from the attendant tug or launch, and sea water is allowed to enter, forcing the air out by the air pipe. As this chamber on one side of the vessel is flooded, the barge tilts and finally automatically overturns depositing the material it contains. The water then runs out from the buoyancy chamber by the air pipe and the vessel rights itself ready to be reloaded.

TEXTILE MACHINERY.—I.

When the hand loom was all that was available to the weaver, the qualities of the work, in design and finish, was almost entirely dependent on the skill and dexterity of the worker. Since those days of simple mechanism great developments have taken place, and now every section of the work has become specialistic and new methods and new machines have been designed to produce the different types of fabric. Progress has been continuous and British textile machinery producers have always maintained their position of supremacy at every stage in the development. This class of machinery is represented by another important group of exhibits at Wembley, and while we cannot at the moment deal with it extensively we make a start with some examples of the products of Messrs. Robert Hall and Sons, Bury, Limited, of Hope Foundry, Bury, Lancs. The machines are illustrated in Figs. 1 to 4 on this and the opposite page.

The provisions of a completely automatic weaving machine has engaged the attention of loom-makers and users for more than a century and progress towards the present position has been made in a number of steps. Development has been due to the efforts of two classes of people, the one possessing an intimate knowledge of the work to be done and the other with the mechanical and design ability to meet the requirements, but with very little experience in the use of textile machines. As these two sets of people worked independently it was only natural that in the early developments machines were produced which were of unsuitable mechanical design or, on the other hand, of a type giving a great deal of trouble to the operator. As experiences grew, however, and better general ideas on the subject became common changes were introduced, and eventually the stage was reached when a reliable and serviceable machine of good design was procurable. A good example of an automatic loom of quite simple construction is shown in Fig. 1. This machine, the design of Messrs. Robert Hall and Sons, Bury, Limited, has many features of great merit. When it is in use, 150 ring bobbins may be placed in the loom and woven off without any further handling. No hand threading is necessary at the loom, and the fixing of weft in a magazine is also not required. Instant stopping takes place when a weft thread breaks or when a bobbin must be changed. The warp stop motion is a reliable piece of mechanism of ingenious design, while the letting-off motion for the warp is completely self-regulating. The cloth doffing arrangement permits pieces to be taken away without stopping the loom and a measuring device is fitted to discontinue the working, when any specified length has been woven for completed pieces or headings. An electric light signal system is combined with the loom, to indicate when it stops from any cause. The light is extinguished immediately the loom is restarted. It is claimed that three persons only are required to look after one hundred looms of this type.

A belt loom designed for the production of cotton, camel hair or hemp driving belts is shown in Fig. 2. It is also suitable for such work as weaving asbestos brake bands and the wide belts used for conveyors. It works on the underpick principle, as is usual in this type of work, and with produce belts of various plies. The shedding is operated from whole plate tappets outside, by means of top and bottom jack levers. These jack levers are connected by adjustable rods and rod couplings. The take-up motion is arranged on the worm and wheel principle, and the belt produced is passed underneath the loom to a coiling mechanism at the back, thus enabling long lengths to be woven. Another interesting example of the machines of Messrs. Robert Hall and Sons, is illustrated in Fig. 3 annexed. This is a

patent loom for weaving horse-hair cloth. For this the horse-hair is drawn through by two needles working simultaneously from both sides of the loom, the hair being in a vertical tube. Each needle, which is in a special carrier, has a slit against which fits a small flat piece of spring steel, kept in position by a spring. This provides the grip. Pressure against the horse-hair releases the spring, which opens this grip and enables one or more hairs, according to the size of the slit in the needle, to be drawn across. There is also an arrangement in the needle carrier to open the grip, so that the hair may be released when it has been drawn across. A special weft motion is furnished in the loom by which the dobby barrel does not turn if the needle fails to catch a hair and thus the shed is not changed. By the arrangement of having needles at both sides, short lengths of hair can be utilised which overlap in the centre.

For the plaiting or folding and measuring of cloth mechanical devices are used and a good example of this type of machine is shown in Fig. 4. The model illustrated has a circular table but others with flat ones are also manufactured. Across the front and back, extending from one side to the other, is a grip rail, the under surface of which is provided with cord, wire or rubber, depending on the class of goods to be folded. As the cloth enters it is laid in plaits of exactly equal length by the oscillating movement of folding blades, and there is a special grip and relieving motion to raise and lower the grip rails at the appropriate periods. Alterations in the setting to obtain other lengths of the folds or plaits is obtainable by a very simple adjustment.

AERONAUTICS.—I.

As aviation is destined to have a far-reaching effect upon the future of the Empire, both as regards its defence and commercial development, it is obviously important that visitors to the exhibition should obtain an accurate impression of its present position, and, as far as may be, of its future possibilities. Only after a complete survey of the whole of the exhibits has been made will it be possible to judge whether or not they are adequate for this purpose, but one exhibit which will itself be of considerable educational value to the general public has been arranged by the Air Ministry in the Government Pavilion. This exhibit is intended to indicate the utility of aircraft in the military and naval services, their possibilities for use as an independent force, and their potentialities as a means of transport. The evolution of aircraft is illustrated by means of a series of scale models of pre-war, war-period and post-war aeroplanes, and other models are arranged to demonstrate the applications of aircraft in military and naval operations. To illustrate the development of civil aviation, a large-scale model of the South of England and North of France, showing the air route between London and Paris, is exhibited, while other models represent the Croydon aerodrome, various Continental air routes, and the Cairo–Baghdad air route. In view of the recent discussion on the Burney airship scheme the working model of a commercial airship base included in this exhibit is noteworthy, and other items of interest in connection with civil aviation are various safety appliances, aero engines and accessories, and meteorological apparatus.

Among the exhibits of private manufacturers of aircraft, the most important appears to be that of Messrs. Vickers, Limited, Vickers' House, Broadway, Westminster, S.W. 1, who illustrate this particular branch of their activities by displaying a number of accurate scale models of aeroplanes designed and constructed at their Weybridge works, together with some full-size accessories for aircraft. Considerable interest attaches to the model of the Vimy-Rolls twin-engined bomber shown, since it will be remembered that it was in a slightly modified form of this machine that the first trans-Atlantic flight was achieved by the late Sir John Alcock and Sir Arthur W. Brown, in June, 1919. Particulars of this epoch-making flight were given in our issue of June 20, 1919, on page 811, and a full account of the machine used will be found in ENGINEERING for May 9 of the same year, on page 604, so that we need not deal further with its characteristics here. By fitting the machine with a specially designed "monocoque" fuselage, incorporating a closed cabin of elliptical section, the Vimy bomber was adapted for commercial purposes, and in this form it is capable of carrying twelve passengers. A model of this machine is shown at Wembley, but we must refer our readers to page 736 of our issue of June 6, 1919, for full particulars of the many interesting features of its design and construction.

More recently Messrs. Vickers have developed a much larger commercial machine, named the Vanguard, and capable of carrying twenty-three passengers. Fig. 3, Plate LI, shows the general appearance of this machine, a model of which is included in the Vickers' exhibit, and a good idea of the scale of the illustration can be obtained from the presence of the two men in the foreground. As will be seen, the machine is a twin-engined tractor biplane fitted with a two-wheeled landing chassis under each of the engine nacelles, and having a fuselage of elliptical section in which is located a large closed cabin. The fuselage is constructed in three parts of which the foremost, containing the passenger cabin and pilot's cockpit, extends well in front of the main planes, thus affording a wide field of vision. Dual control of the normal type is provided, but a compensating device is fitted in the elevator control to enable the pilot to fly at any desired speed with his hands off the wheel. The passenger cabin is situated immediately behind the cockpit, access being obtained to it through a side door located aft of the main planes and thus at a considerable distance from the propellers. A lavatory compartment is fitted up behind the cabin and beside this is a space for luggage, which can also be stored in a bulkhead under the cockpit. For the conveyance of mails and small freight, external lockers are fitted below the cabin floor. The whole of the front portion of the fuselage is constructed of a plywood shell mounted on longerons and hollow spruce frames of box section, while the central portion is built up of Ryan wooden tubular longerons and bulkhead struts connected at the angles by steel fittings braced with swaged wires and faired with laths and fabric. The rear portion of the fuselage consists of a short section constructed of steel tubes to which the tail planes and tail skid are secured. The tail is

THE "VIGET" LIGHT AEROPLANE.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, ENGINEERS, WEYBRIDGE.

FIG. 1. REAR VIEW OF MACHINE READY FOR FLIGHT.

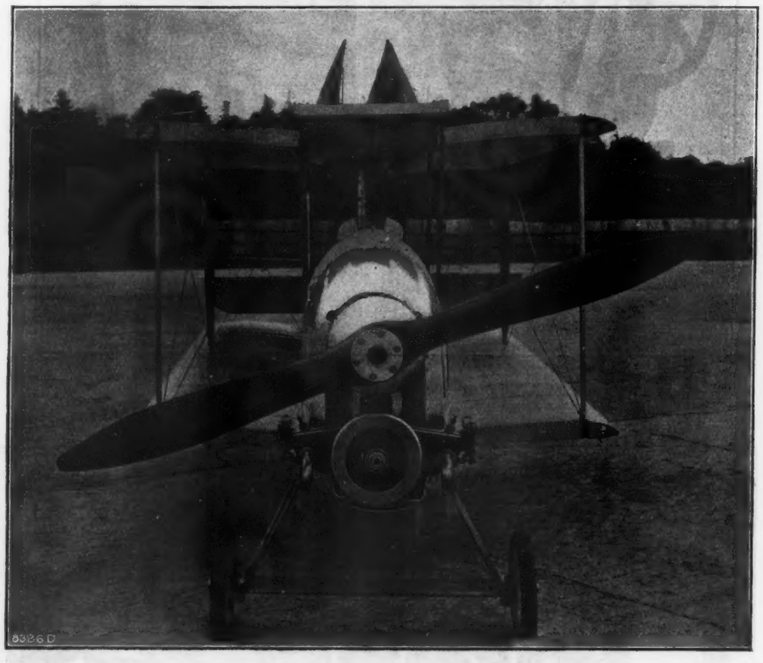


FIG. 2. FRONT VIEW OF MACHINE WITH WINGS FOLDED.

of the biplane type and between the planes are fitted twin "K" fins and rudders with steel tubular profiles and wooden former ribs. The rudder area, it may be mentioned, is sufficient to enable the machine to fly on a straight course with one engine out of action.

The main planes have a span of 88 ft., but the part beyond the outer engine struts can be folded back, thus reducing the overall width of the machine, when folded, to 46 ft. 3 in. The wing chord is 13 ft., so that the main plane area is 2,182 sq. ft., and since the weight of the machine, fully loaded, is 17,600 lb., the wing loading is about 8 lb. per square foot. With two Napier-Lion engines developing 438 h.p. each, the loading per horse-power is 20 lb. The length of the machine overall is 53 ft. and the height 17 ft. 3 in. The construction of the biplane cellule calls for no particular comment, except that we may mention that the internal compression struts in the main planes are of Ryan wood tubing and the external struts are composed of segmented spruce sections made under Vickers-Ryan patents.

The upper plane, it will be noticed, has no dihedral angle, but the lower plane has a dihedral of 4 deg. The engines are mounted on ash bearers supported on steel tubular struts, and are covered with a metal cowling, the form of which can be seen in Fig. 3. Petrol is supplied to the carburettors by gravity from a service tank which is filled from the main tank by wind-driven centrifugal pumps. The surplus petrol returns through an overflow pipe to the main tank, which is located under the floor of the cabin. The radiators are mounted in front of the engine nacelles, as shown in the illustration, and are fitted with adjustable shutters to enable the pilot to regulate the temperature of the cooling water. The machine has been designed for a maximum speed near the ground level of 100 miles per hour and for a minimum speed of 47 miles per hour. Its climbing power is such that a height of 5,000 ft. can be reached in 23 mins., and the petrol storage capacity provided gives a range of 470 miles at cruising speed.

Another commercial machine exhibited in model form by Messrs. Vickers is known as the "Vulcan" and is provided with an enclosed cabin with accommodation for six passengers. When fitted with a Rolls-Royce Eagle IX engine, developing 397 h.p. and driving a single tractor screw, the guaranteed performance is 105 miles per hour near the ground level, climb to 6,000 ft. in 21·7 mins., and minimum flying speed 45 miles per hour. The main dimensions of the machine are: length overall, 38 ft.; height, 14 ft. 3 in.; wing span, 49 ft.; chord, 9 ft. 3 in.; wing area, 834 sq. ft.; wing loading, 7·6 lb. per square foot; loading per horse-power, 16 lb. The weight, fully loaded, is 6,400 lb.

For military purposes high performance is of greater importance than economical operation, so that, in general, the design of military aircraft differs materially from that of commercial machines. As an example of military aircraft design, we illustrate, in Fig. 4, on Plate LI, a two-seater, dual-control tractor biplane for reconnaissance work and bombing, a model of which is shown by Messrs. Vickers. The machine, which has been named the Valparaiso, is fitted with a single Napier-Lion high-compression engine developing 486 h.p. and giving a speed of 127 miles per hour at a height of 10,000 ft. This height is reached in 16 minutes and the minimum flying speed of the machine is 50 miles per hour. These figures represent the performance of the machine in the fully-loaded condition in which its weight is 5,450 lb.; of the latter figure 850 lb. are allowed for military equipment, including a Vickers' gun, ammunition, and four bombs of 1 cwt. each.

The Valparaiso has an overall length of 29 ft. and a height of 12 ft., while the wings which are set with a considerable stagger, as shown in our illustration, have an aggregate area of 590 sq. ft.; the stagger actually amounts to 39 ins. The wing loading, obtained from the weight given above, is 9·25 lb. per square feet, and the horse-power loading is 11·2 lb. The span and chord of the upper wing are 44 ft. and 8 ft. 3 in., respectively, while the corresponding dimensions of the lower wing are 38 ft. 6 in. and 7 ft.; the lower wing only has a dihedral angle of 3 deg. The machine as illustrated is, of course, intended for land service, but it is also constructed as a float seaplane with the same total weight but with a slightly reduced performance.

The model shown of the Viking amphibian machine, which is a boat seaplane with retractable landing wheels, will probably attract considerable attention at Wembley, since it is the prototype of the machine in which Squadron-Leader MacLaren is now attempting his flight round the world. We illustrated and described the construction of the Viking so fully in our issue of April 22, 1921, on page 486, that we must now pass on to Messrs. Vickers' remaining aircraft exhibit, which is a model of the Viget light aeroplane—a machine designed and constructed for the competitive trials of this class of aircraft carried out at Lympne in October last. As will be seen from the general view of the machine reproduced in Fig. 1 on page 550, it is a tractor biplane of normal design, except with respect to its power unit and overall dimensions; the latter it may be interesting to contrast with those of the Vanguard machine illustrated in Fig. 3 on Plate LI.

In the case of the Viget, the wing span is 25 ft., but with the wings folded back as shown in Fig. 2, the overall width of the machine is only 7 ft. 6 in. The other main dimensions are: overall length, 17 ft. 3 in. and height, 7 ft. 3 in., so that the machine can be housed in a small garage. The wings are of standard construction and call for no particular comment, except that it may be mentioned that the ailerons extend along the whole of the span from the tips to the edge of the centre section. The chord of both wings is 4 ft. 3 in. and the effective area is 200 sq. ft. so that, since the total weight of the machine ready for the air and carrying a pilot weighing 12 stone is 625 lb., the wing loading works out at just over 3 lb. per square foot. The fuselage is a braced structure with square section longerons and struts of cruciform section, both of spruce, connected by fittings formed of Duralumin plate; it carries a monoplane tail with a vertical fin and rudder which can be distinguished in Fig. 1. The pilot's cockpit is located between the main planes, and to facilitate access to it a door is provided in the fairing on the port side of the machine. The landing chassis is of the ordinary V-type constructed of steel streamline tubes and provided with rubber shock absorbers.

The power unit, which is well shown in Fig. 2, comprises a twin opposed-cylinder air-cooled Douglas engine of 750 c.c. cylinder capacity driving a two-bladed propeller through a roller chain which gives a speed-reduction ratio of 2½ to 1; the neat cowling of the propeller sprocket and engine should be particularly noticed. A fireproof bulkhead separates the engine housing from the fuselage, in the fairing of which a petrol tank holding 2 gallons is located at a sufficient height above the carburettor to give a reliable gravity feed. The engine, we may mention, develops about 20 h.p. at 3,500 r.p.m. and this gives the machine a speed of about 65 miles per hour. The minimum flying speed is 30 m.p.h., and the cruising speed 55 m.p.h., while the time occupied in climbing to 5,000 feet is 20 minutes. At the cruising speed mentioned a distance of 60 miles can be covered in a little more than an hour with a consumption of one gallon of petrol. These figures, we submit, are of considerable interest as an indication of the economic value of the light aeroplane as a means of transport.

The most important component of the aeroplane is, of course, its engine and at the present time considerable attention is being given to the static radial air-cooled type. The obvious advantages of this type of engine, viz., light weight, compactness, and absence of radiators and cooling-water system, have long been appreciated by aeroplane designers, but the attempts made to develop the type in the higher powers required during the later period of the war were generally unsuccessful from the point of view of reliability in service. In all aero engines this characteristic is of such importance that other considerations must take second place, and the superior reliability of water-cooled engines of the straight-line and V types led to their more general adoption. Within the last two or three years, however, the Bristol Aeroplane Company, Limited, Filton House, Bristol, have developed engines of the static radial air-cooled type, which while leaving nothing to be desired from the point of view of reliability, fully retain the inherent advantages of the type.

One of these engines, known as the Bristol "Jupiter," is included in the firm's exhibit at Wembley, and this we illustrate in Figs. 5 and 6 on Plate LII. This engine, we may say, has successfully passed the severe type tests of the British Air Ministry and of the French Government, and we may also mention, in connection with the Air Ministry tests, that it was the first air-cooled engine to do so and also had a lower weight per horse-power than any other engine complying with the conditions imposed. After completing the test, the engine was taken down, examined and measured, and then submitted to a 150-hour reliability test under the supervision of the Aeronautical Inspection Directorate. During this trial, which included a non-stop run of 50 hours duration, the engine developed 342 brake horse-power at 1,575 r.p.m., and the petrol consumption worked out at 0·614 pint per brake horse-power hour, while the lubricating oil used amounted to 0·0344 pint per brake horse-power hour.

As will be seen from our illustrations, the engine has nine cylinders, disposed in one plane round an aluminium crank-case, and having equal angles of 40 degrees between adjacent axes. The cylinders are of 5·75 in. bore and the piston stroke is 7·5 in., while the compression ratio is 5 : 1. They are of composite construction, the barrel being of steel machined with integral fins from drop forgings, while the heads are cast from a special aluminium alloy. Two inlet and two exhaust valves are provided in each cylinder head, the valves being operated through the medium of tappets, push rods and a special form of compensated rocker gear, by a cam sleeve, which runs concentrically with the crankshaft and is driven from it by epicyclic gearing. The compensated rocker gear, we should explain, is provided to keep the tappet clearance constant irrespective of the expansion of the cylinders. The pistons are die castings of aluminium alloy and are each provided with two gas rings and one oil-scraper ring. One master rod and eight articulated rods of I-section, drop forged from nickel-chrome steel and carefully balanced, are used to transmit the power to the crankshaft. The latter is of the single-throw type, machined in one piece from a nickel-chrome steel forging, and runs in three main roller bearings. The crank webs are extended on the side opposite to the crank-pin to form balance weights, and each web is fitted with a mortised auxiliary balance weight. The propeller is driven directly from the crankshaft, so that it runs at the same speed as the engine, and the hub is mounted on tapered splines and secured with a split conical ring and nut at the front end of the shaft.

Two main castings, joined on the cylinder centre line by means of collar bolts, form the crank-case, which is closed at the front end by an aluminium cover and steel thrust housing of which the latter carries a double thrust case to take the propeller thrust as well as one of the radial roller bearings supporting the crankshaft; the other two roller bearings are carried by the main castings in bronze bushes. The cam gear is situated in a chamber forward of the intermediate bearing, and the tappets are in an annular recess concentric with this chamber. Behind the rear wall of the crank-case is an annular chamber housing the induction spiral, which we shall refer to later, and on the rear cover are mounted two B.T.H.-A.Q. 9 type magnetos which are driven by bevel gearing from the crankshaft. This cam also carries a compound oil pump of the gear type comprising one pressure unit and one scavenging unit, both of which are fitted with filters.

The patented induction system used on this engine is an interesting and important feature of its design, the object of the arrangement adopted being to ensure an even distribution of correctly proportioned mixture to each of the cylinders. As shown in Fig. 6, three carburettors, which are modified forms of the Claudel-Hobson H.C.8 type, are provided, and these are connected to the annular chamber, above referred to, by means of an elbow casting clearly visible in the illustration. The annular chamber is of circular cross section, and in it is fitted an aluminium casting of trefoil section, twisted so as to form what may be described as a three-start screw of quick pitch. This casting fits closely to the inner walls of the annular chamber and thus divides it into three

100-H.P. BRISTOL "LUCIFER" AEROPLANE ENGINE.

CONSTRUCTED BY THE BRISTOL AEROPLANE COMPANY, LIMITED, ENGINEERS, BRISTOL.

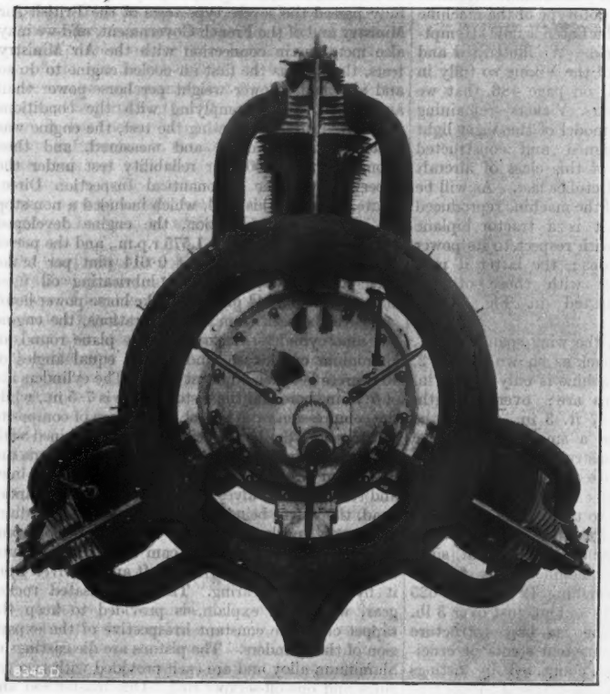


FIG. 7. FRONT VIEW OF ENGINE, SHOWING EXHAUST SYSTEM.

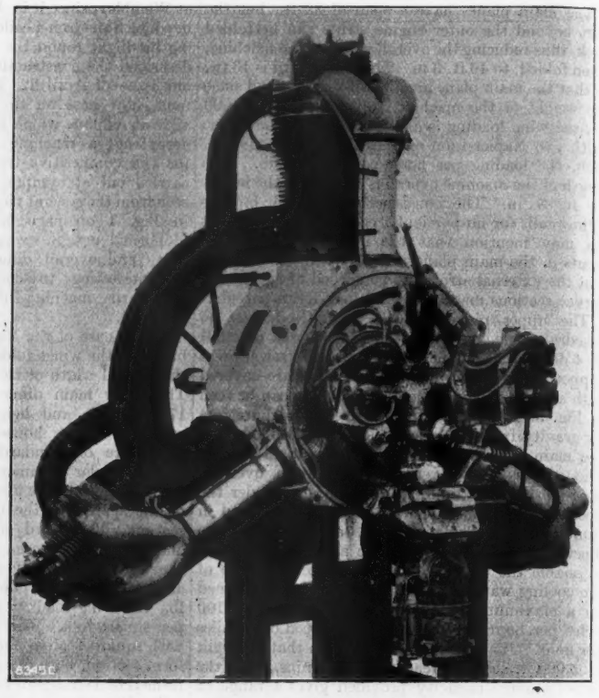


FIG. 8. REAR VIEW OF ENGINE, SHOWING MAGNETOS AND CARBURETTOR.

separate helical passages, to each of which one of the carburettors is connected. The cylinders are connected to the annular chamber by radial aluminium induction pipes, shown in Fig. 6, and the arrangements are such that three cylinders, each separated by an angle of 120 degrees, communicate with the same helical passage in the annular chamber and are consequently connected to the same carburettor. This arrangement not only eliminates the effects of mutual interference between the cylinders as they draw in their charges but also serves to divide them into three balanced groups. The engine can thus operate with one, or even with two, carburettors out of action (running on six or on three cylinders) without undue vibration. The radial induction pipes are provided with expansion joints and are fitted with breeches pieces at the outer ends communicating with the two inlet valves of each cylinder.

The maximum output of the engine is 400 brake horse-power at 1,600 r.p.m., and the normal output 380 brake horse-power at 1,575 r.p.m., both at the ground level. At the latter speed and output the piston speed is 1,969 ft. per minute and the brake mean-effective pressure is 112 lb. per square inch, while the petrol and oil consumptions specified by the makers are 0·58 pint and 0·0289 pint, both per brake horse-power per hour. The total weight of the engine without fuel or oil is 740 lb., or 1·9 lb. per horse-power; with fuel and oil for a 6-hour run the corresponding figures would be 1,330 lb. total weight and 3·41 lb. per brake horse-power.

The "Jupiter" engine has now been fitted to many different types of military and commercial aircraft of both British and foreign design and has given satisfactory results in service as well as under test conditions. As evidence of this we may mention that in March of last year a Spad-Berline six-seater machine, piloted by M. Casale and fitted with a "Jupiter" engine, attained a record height of 7,339 metres (24,100 ft.) while carrying a useful load of 250 kilogrammes (551 lb.) in addition to the weight of the pilot and fuel. During this test the height of 6,000 metres (19,700 ft.) was reached in 21 minutes and this, we understand, is an improvement on the performance of the leading types of military scouting aircraft.

Another exhibit of the Bristol Company is their "Lucifer" engine, which is also of the static radial air-cooled type, but of lower power, being intended for use on the smaller types of commercial aircraft and for employment on instructional machines, &c. It has been designed with a view to obtaining exceptional reliability combined with long life and economy in fuel and oil consumption, but no attempt has been made to cut weight unduly or to obtain the highest possible efficiency. The makers state, however, that the engine can be relied upon to run for long periods without overhauling and that its general performance and reliability compare favourably with those of a modern motor-car engine. The "Lucifer" engine develops 108 brake horse-power at its normal speed of 1,600 r.p.m. and 118·5 brake horse-power at its maximum speed of 1,760 r.p.m., the petrol consumption with the former output being 0·6 pint per brake horse-power hour and the oil consumption 0·040 pint per brake horse-power hour. The total weight of the engine, with hand starter and decompressor but without fuel or oil, is 325 lb., which is equivalent to 3 lb. per horse-power at the normal output.

Front and rear views of the engine are given in Figs. 7 and 8 above, and from these it will be seen that there are three cylinders bolted on to an aluminium crankcase with angles of 120 deg. between their axes and arranged in the form of an inverted "Y." The cylinders are similar in design and construction to those of the "Jupiter" engine, described above, and have the same internal diameter, viz.: 5·75 in.; the piston stroke, however, is only 6·25 in. in the case of the "Lucifer" engine. The arrangement of the valves and valve gear is generally similar to that of the Jupiter engine, but the cam drive is by simple reduction gear instead of by epicyclic gearing. Aluminium alloy pistons fitted with full floating gudgeon pins and three rings (two gas and one scraper) are used, and they are connected to the single-throw crankshaft by one master connecting rod, which has a split big end with a bronze-backed and babbitted bush, and two articulated rods attached by wrist pins to the master connecting rod. The crankshaft runs in roller bearings housed in the crankcase, which is an aluminium casting of barrel form, and is attached to the fuselage by a 9-bolt circular flange, clearly shown in Fig. 8.

The exhaust and air inlet system adopted on the engine is the result of lengthy investigations and extensive experimental work, both on the bench and in the air. As shown in our illustrations, the exhaust gases from each valve are led by separate pipe connections to a ring silencer, supported by rods from the front of the crankcase. The gases leave the silencer by a single outlet at the bottom, and from this they are led through the carburettor intake in order to heat the incoming air. The arrangement, we understand, has given satisfactory results in prolonged flying tests under varied conditions and is now fitted on all engines of this class supplied by the makers. A single Claudel-Hobson modified H.C. 8 type carburettor is employed and this is connected by an oil-heated elbow, shown in Fig. 8, to an annular chamber cored in the back of the crankcase casting, the chamber being connected to the inlet valves by radial induction pipes of aluminium. Dual ignition is provided by two Thomson-Bennett magnetos mounted on the rear cover of the crankcase and two sparking plugs are fitted in each cylinder. The pressure system of lubrication is employed, the oil being handled by two gear-type oil pumps, one pressure and one scavenging. The pressure pump is fitted with a relief valve and delivers oil through a filter direct to the crankshaft and timing gear. A filter is also fitted on the scavenging pump and both filters are easily detachable for cleaning purposes. For starting the engine, a half-compression cam and hand-turning gear are provided.

This engine has also passed the British Air Ministry Type Test, the particular example tested having been previously run for 155 hours 14 minutes, part of which was actual flying time as the power unit of an experimental machine. The type test involves 50 hours running at 90 per cent. full power and includes two non-stop runs each of 10 hours duration. High-speed, high-power, slow-running and acceleration tests were also carried out with satisfactory results, and in the subsequent examination, the general condition of the engine was found to be

excellent. After re-erection, the engine was run at full throttle for one hour, developing 118 brake horse-power at 1,760 r.p.m., and was also subjected to a further high-speed test in which a speed of 1,850 r.p.m. was reached. While referring to this engine we may mention that it has now been fitted to many different types of aircraft and has given excellent results in numerous aerial competitions, as well as under ordinary flying conditions.

The Bristol Company are showing their "Cherub" engine for light aircraft. This we hope to deal with later, and their exhibit also includes the "Bristol" gas starter for all types of internal-combustion engines, having 6 or more cylinders. The starter consists of a small air-cooled, single-cylinder, two-cycle engine driving a pumping cylinder, which draws a supply of petrol vapour and air from the carburettor of the starter engine and delivers it under pressure to the cylinders of the main engine. The delivery of the mixture to the latter is controlled by a small disc-valve distributor driven from the main engine at half the crankshaft speed and arranged so that the mixture enters the cylinders, firstly on the firing stroke, and secondly for a part of the induction stroke. To avoid the loss of pressure which would occur from the escape of gas through the open inlet valves on the induction stroke, the port in the distributor is first closed during this period by a spring-loaded mushroom valve, but when the main engine begins to turn freely, a hand lever is raised to open the valve referred to, gas then being admitted on the induction-stroke. After a complete revolution in this condition, the cylinders and the whole of the induction system are thus filled with gas. Although the starter engine has only one cylinder it is fitted with a two-cylinder type magneto and the second ignition lead is connected to the distributor of the magneto of the main engine. For the first part of the starting operation, this second lead is short-circuited, but when the main engine is turning freely and has been filled with gas as described, the short-circuiting switch is opened and the engine then fires and picks up on its own carburettors. A non-return valve is fitted in the starter connection to each cylinder of the main engine to isolate the starter when the engine is running normally.

The starter will maintain a gas pressure of 140 lb. per square inch, and it is capable of starting high-speed petrol engines with cylinder capacities up to 2,500 cub. in. or slow-speed oil engines up to 5,000 cub. in. capacity An important feature of the arrangement is the fact that the only connections between the main engine and the starter are a small bore pipe and a high-tension lead, and it is thus possible to locate the starter in any convenient position up to 20 ft. from the engine. The weight of the starter unit is 50 lb., so that it is suitable for use with aircraft engines, and as the starter engine can be run continuously without overheating it can be used for driving auxiliaries such as wireless generators. In the Jupiter engine, we may mention provision is made in the cylinders for fitting the non-return valves for the gas starter and a distributor is mounted on the rear cover.

AUSTRALIA AND THE WORLD POWER CONFERENCE.—The first quarterly bulletin, for January, issued by the Institution of Engineers, Australia, refers to a communication addressed to the Federal Engineering Council, Australia, from the Organising Director of the World Power Conference, suggesting the formation of a National Committee for the representation of Australian interests. This communication was subsequently referred to the Institution. Representations were made to the Federal Government urging the importance to Australia and Australian interests of the Commonwealth being represented at the Conference, and submitting that the Institution was particularly competent to undertake the preparation of a report on the power resources of the Commonwealth. The Government agreed to the proposal, authorised the Institution to submit a report for the Commonwealth as a whole, and subsidised the work. The preliminary organisation is well in hand, and a considerable amount of work has been done in the collection and collation of the necessary data. The Commonwealth Government has whole-heartedly supported the undertaking and has appealed for the co-operation and assistance of all who may be in a position to supply authentic information suitable for inclusion in the report. The Conference will be held, as is well known, in London from June 30 to July 12 in connection with the British Empire Exhibition.

MACHINE TOOLS.—I.

The majority of the machine tool firms are not exhibiting at Wembley, but some very interesting machines of this class are to be seen on various stands. Among these is that of Messrs. Vickers Limited, of Vickers House, Broadway, Westminster. As will be well known Messrs. Vickers have made broaching machines for a number of years, and a full range of their products in this line is to be seen at the Exhibition. They also, however, show other machine tools of their manufacture, of which two are illustrated in Figs. 1 and 2, on Plate LIII. The first of these is the firm's tool room lathe. The demands on a machine of this class are exacting, and the tool has been designed to fulfil the requirements of tool room production. Quick output and ease of control have been kept in view throughout the design. The bed is of box section approximately 10 in. deep and 9 in. wide, and is 6 ft. in length overall. It is provided with four rails running its full length. The two outer rails are V-shaped and are allocated for the carriage, of the inner rails accommodating the tail stock, one has a flat and the other a V-tread. There are also three inverted flat rail guides used for the carriage and tailstock. The carriage is of H-shape and utilizes two of the flat lower guides. It carries a compound slide rest and a hand or power-operated cross-slide, which may also be connected to the taper-turning attachment. The tailstock is adjustable for taper turning, and can be clamped in any position along the bed by means of an eccentric quick-release clamp. The headstock is provided with a hollow spindle and is cone-pulley driven with back gear. It is fitted with a draw-back collet chuck and a set of eight collets. The spindle runs in adjustable ring-oiled gunmetal bearings and the thrust is taken on hardened washers. The lathe has a change gear box and screw-cutting lead screw, automatic feeds, etc. The height of the centres is 6½ in., the swing over the bed being 15 in. and over the carriage 8 in. The length between the centres is 35 in. and the cross-feed 8¼ in. The hole through the spindle is 1 in. diam. The change gear-box gives 40 speeds for machining and 40 pitches for screw-cutting. The projected floor space occupied is 86 in. by 38 in., and the weight excluding the countershaft is 19 cwt. 3 qr.

The second exhibit illustrated is a gear-shaping machine which is likely to arouse considerable interest. The machine is designed to generate a range of gears which normally could not be produced by a single tool. It will cut external gears from zero to 44 in. in diam. and 6 in. deep and internal gears to 50 in. in diam. and 4 in. deep. The pitch range is from 48 to 3 for diametral pitch, ½ in. to 1 in. for circumferential pitch and 1 to 8 for module wheels. The cutter spindle of the machine is mounted in bearings which are housed in a sliding ram. The spindle rotates on its axis and is controlled by the index gear. It also moves up and down with the ram, which is operated by means of a rack and pinion, the stroke of the ram being adjustable both for position and traverse. The ram is carried by an overhung box-section head which also carries the main drive. This head is formed with an ample recess behind the cutter to provide the necessary tool clearance when internal gears are being cut. The worktable is carried on vees on the box-shaped bed and is held down by flat track guides. The table is driven by a worm wheel and the socket which carries the wheel and table is arranged to take a work arbor. Indexing gear is provided with the table which has a relieving motion which can be made to operate in either direction and withdraws the work from the cutter on its return upward or downward stroke.

The control gear consists of the gear case, the drum for regulating the depth of cut in feed and the timing wheel which automatically controls the movements of the cutter and the work so that they synchronise. The change and pitch gear is a simplified form of the ordinary screw-cutting lathe-change gear. The main drive of the machine is from a cone pulley, and is either direct or through a back gear depending on the work being done. There are six ram speeds, three with direct drive and three through the back gear, while the control gear has three changes for each of the six speeds of the ram. The dimensions of the bed of the machine on the floor are 2 ft. 10 in. by 4 ft. 6 in. and the projected floor space is 3 ft. 3 in. by 6 ft. 6 in. The overall height is 7 ft. and the weight 37 cwt.

The use of machinery in woodworking has grown extensively in recent years, and while much of the development has been made in heavy plant designed for use at exceptionally high speeds on repetition work, the provision of lighter types of machinery intended for a smaller output, but covering a greater variety of work, has not been neglected. In this second group must be placed those types of machines which are of suitable size for easy transportation to the site of the works in which their product is put to use. In the provision of the lighter types of machinery designed for all classes of work The Dominion Machinery Company, Limited, of Union Street South, Halifax, has attained a great measure of success and many new and improved designs have recently been introduced in order that the field of service might be increased and the efficiency improved.

A very useful tool of the general woodworking type has been produced by the firm for some years under the name of the Elliot woodworker. It has found extensive use at home and abroad and there are at the present time some 1,500 in service in Great Britain alone. Further demands of the trade, however, for the introduction of features permitting an extension of the scope of the tool, have been met in the Super-Elliot Woodworker which is illustrated in Figs. 3 and 4, on Plate LIV. This machine, though comparatively small and driven by a 3-h.p. motor, will perform a great variety of work, such as rip or cross-cut sawing, boring, trenching, moulding, the production of house stair stringers, tenoning, surfacing, mitreing and rebating. It consequently must be classed as a universal tool. Not only can this catalogue of work be performed with the machine but it is not necessary to build upon it any extra fitments or to alter its mode of operation when changing from one type of work to another, except for the fitting of the actual tool. In the illustrations, Figs. 3 and 4, this woodworking machine is arranged for rip sawing and cross-cut sawing. The motor and saw are mounted on slide rails, which are supported in such a way as to permit setting to work at any angle. As the material is fed into the machine in the usual way, any length of material with a thickness up to 6 inches can be sawn longitudinally 3 inches depth from each side, and cross-cutting is possible up to 24 inches width and 6 inches thick in two cuts, one from each side, when the standard saw of 12 inches diameter is in use. When cross-cutting the saw is carried through the material by the movement of the motor and the saw, along the slide. In this sawing work a speed of 3,500 r.p.m. is maintained, which is sufficiently high to give very good finish in the work. The arrangement to permit tilting of the table is clearly shown in the illustrations, Figs. 3 and 4. Just behind the saw blade in Fig. 3 is seen the graduated support for the slide. This has stops fitted to it for longitudinal or cross-cut work, and also at 45 degrees, but it can be set at intermediate angles by the use of the circular graduated scale. On the back of the machine there is a surfacing tool, the cutter block for which is driven by a belt from the motor when the line of the slide lies in the length of the machine. The belt is kept tight by a spring-mounted jockey carried by the slide rail on which the motor sits. A speed of 4,000 to 4,500 r.p.m. is obtained for the rotating cutter block. Guides and guards are provided to permit accurate working and ensure safety.

A chain and hollow chisel mortiser, made by the same firm, is shown in Figs. 5 and 6. The arrangement of the belt drive is shown in Fig. 5. The main driving pulley is at the bottom of the machine, and the belt is taken over two jockeys carried at the top. It then passes to the spindle pulley. This latter is fixed on the spindle which goes through the body of the machine and carries at the other end the sprocket which drives the chain. This pulley is raised and lowered with the cutting device, and to allow of this one of the jockey pulleys is fixed to the frame of the machine and the support for the spindle of the other works in square slides and has a spring below it to ensure that the belt is kept tight. A splinter pad is provided to prevent the timber

SPINDLE-MOULDING MACHINE.

CONSTRUCTED BY THE DOMINION MACHINERY COMPANY, LIMITED, HALIFAX.

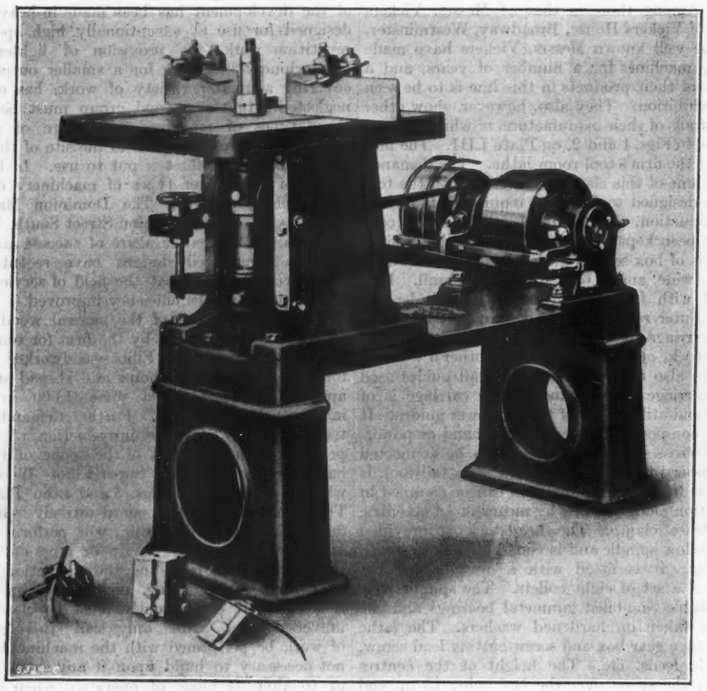


FIG. 7. SPINDLE-MOULDING MACHINE.

being splintered when the chain is in operation. The chain cutter may be replaced by a hollow chisel if the chain sprocket is removed and gear wheels introduced to rotate the cutter. This machine, which needs 1½ to 2 h.p. to drive it, will deal with timber up to dimensions of 11 in. by 7 in. and will mortise to a depth of 5½ in.

A spindle-moulding machine, also a product of the Dominion Machinery Company, Limited, is shown on Fig. 7 above. The spindle is turned from a solid cast-steel bar and runs on ball bearings. Arrangements are provided for the raising and lowering of the cutter slide by means of a screw working through a threaded hole in an extension of the casting at the foot of the spindle. The hand-wheel for this purpose is conveniently placed and a locking screw is provided to keep the spindle in place at any setting. The table is 24 in. square and has two planed grooves across it to slide the fences across. Each of these fences is fitted with a sliding front plate so that the opening between them may be regulated. Pressure bars and springs are fitted and enable the work to be retained in proper position for the performance of accurate cutting. The spindle is run at a speed of 5,000 to 6,000 r.p.m., which ensures good finish in the work.

THE GAS INDUSTRY AT WEMBLEY.—The British Gas Industry is represented at Wembley by a Joint Exhibit to which nearly all of the 1,400 company and municipal undertakings of the kingdom and a number from overseas have subscribed, as well as the manufacturers of gas plant and appliances. The British Empire Gas Exhibit is situated in the centre of the Palace of Industry under the Chairmanship of Mr. David Milne Watson, Governor of the Gas Light and Coke Company, the largest gas undertaking in the world.

THE LONDON CHAMBER OF COMMERCE.—The British Chamber of Commerce in Brazil, Avenida Rio Branco, Rio de Janeiro, has informed its members, by a note in its monthly bulletin No. 59, that the London Chamber of Commerce provides a branch office within the exhibition at the Northern entrance to the Palace of Industry, adding that the use of this branch office is offered to business men from overseas who bring letters of introduction from their local Chamber of Commerce. A cordial invitation, their bulletin further states, has been extended to members of the Rio Chamber who are visiting England during the Exhibition.

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SOUTH AFRICA AT WEMBLEY.—A special issue of *The Star*, Johannesburg, dated March 11, says that South Africa's thoughts and hopes will be more than ever diverted overseas this year. A considerable proportion of the Union's population will be at Wembley, and will there have opportunities, in common with the visitors from sister Dominions, of realising what are the resources and potentialities of the British Empire. The Empire Exhibition, the journal adds, is a great opportunity for Dominion window-dressing. The natural resources of South Africa, its geographical situation and climatic conditions, on the whole favourable to the exploitation of those resources, must in the long run outweigh all temporary and artificial restrictions.

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ENGINEERING.

FRIDAY, APRIL 25, 1924.

EMPIRE DEVELOPMENT.

THE fact that this country has come better out of the Great War than any other in Europe is not owing to our losses, either material or human, being less grave than those of our allies or enemies. It has been due to a businesslike policy and a common sense of which we may quite fairly be proud. Actually we are not proud of it, because we take it as a matter of course. There is, fortunately, enough of mother wit in this country to make us realise, with Mr. Micawber, that a surplus of sixpence at the end of the year represents solvency, while a deficit of sixpence spells bankruptcy. It is a triumph for British finance that at no time during the difficult period through which we have passed was there the shadow of a suggestion that this country was not solvent.

Our financial record since 1918 is, however, a triumph for more than British finance. It is a triumph for what there is no better name for than British sense. No series of governments could have handled our monetary affairs in the way they have been handled unless the goodwill of the country had been behind the general financial policy. It is true that there is a good deal of doctrine talked nowadays with which we, for instance, are not in agreement, but, fortunately, this doctrine has not to any serious extent been translated into action, and there need be no hesitation in claiming that this country as a whole is in favour of paying its debts and paying its way.

Although Mr. Micawber's surplus of sixpence may spell solvency, it does not necessarily spell any great prosperity, and while our financial policy since the war has ensured the sixpence, it would be well if some means could be formed to increase our useful activity, and so possibly either to turn that sixpence into ninepence or ensure it with somewhat less of strain. The productive performance of this country is, according to Lord Weir, about 16 per cent. worse than in 1913. This figure does not, as we understand it, indicate that our output is 16 per cent. less, since we have an increase of population of some million and a-half. Even allowing for the increase of population, however, the fall in productive efficiency is such that we have not yet reached our pre-war output. This condition is coupled with a demand for, and an expectation of, an improvement in the standard of living from the great mass of our population. As the two things are incompatible that improved standard of living is not on the average being achieved. The economic situation of this country is such that the standard of living is, and is likely to remain, a direct measure of our exports. Only by raising exports can the standard be raised.

Our present relatively poor performance as a manufacturing nation compared with our own achievements in the past has many causes, including a reduction in working hours and other matters with which we do not propose to deal for the moment. One of the great causes, however, is undoubtedly a seriously diminished demand from many of our foreign markets. This diminished demand is due to the impoverishment and unsettlement of Europe and their reaction in foreign markets, such as South America, and, despite reports and conferences, it would be wise to assume that the present condition will not pass in any immediate future. In such circumstances a country situated as we are would be wise to consider the possibilities of the other outlets for its products and, fortunately, we have not to look far. Within the limits of our own Empire there are potential markets, which, when fully developed, will call for a supply of manufactured goods which may raise the output and, incidentally, the prosperity of this country to a point they have never yet reached.

The actual and potential trade which is being, and is to be, done within the Empire is neither unknown to, nor ignored by, our manufacturers, but since each individual manufacturer is, quite naturally, inclined to direct his main efforts to channels with which he is familiar, it is well that any opportunity which arises to direct attention to the possibilities of the whole Empire field should be taken full advantage of. Such an opportunity has been created by the magnificent exhibition at Wembley, which was opened by the King on Wednesday, and it is much to be hoped that every manufacturer in the kingdoms will make the event an opportunity of studying and getting in touch with new markets. The exhibition has been conceived and planned by no means merely to foster inter-Empire trade, but that is one of its important functions, and in as far as it results in increased foreign trade for our great Dominions, Colonies and Dependencies, that, in turn, will react favourably on the manufactured output of this country, which is the keystone of our prosperity and even of our existence.

A point of view has existed in the past in this country, and still persists to some extent, which would make all efforts directed towards Empire development in some curious way undesirable and even unworthy. This attitude of mind has perhaps been less in evidence of late years, possibly because the serious question of our export trade may have influenced even the most convinced anti-Imperialist. Certain it is that any views of the kind to which we refer would be singularly unfitting in connection with the great Imperial effort which is being made at Wembley this year, and it is matter for satisfaction and hope that all parties seem ready to join in assisting towards the success of that effort. Some part of the attitude of mind to which we have referred has been due to an idea that the development of Empire trade was a matter of interest to manufacturers, but that labour had little or no concern with it. One may trust this idea is passing. We have said that our exports are a measure of our standard of living, and that standard of living is of necessity one of the first interests of labour and all those for whom official Labour speaks.

In view of what a fully developed Empire may mean to the prosperity of this country, one cannot feel that any party in the State has done all that it might have done to foster that development. The Empire Exhibition is a magnificent effort, which is a credit to all who have been concerned with it, but there are other matters, the handling of which have reflected no credit on any party—for instance, the Imperial wireless chain. The history of this has been a series of vacillations and delays, which appear to owe their origin to the inadequacies of a bureaucratic department. It is not the practice of strong Ministers, however, to allow important developments to be held up by any department, and the history of this matter has been unworthy of the country. It is to the credit of the

present Government that some arrangement at length appears likely to be made which may at last lead to a start being made.

Since many parts of the Empire cannot develop fully without a great increase of population, it is to be hoped that the attractive display which the great Dominions have staged at Wembley may do something to assist emigration from this country. The various emigration schemes do not in the past appear to have attracted any great enthusiasm in labour circles, but both from the point of view of the emigrant and of his colleague who is left behind, any schemes of this kind are likely to do much for labour, both by providing new prospects for those who utilise them and a better prosperity for those who do not. So much is the well-being of every individual in this country bound up with an increased manufactured output that anything which will assist the development of the outlying parts of the Empire must react favourably on the prospects of labour at home.

That we look upon this exhibition as marking an important stage in the history of the British Empire is made evident by the large amount of our space which we are devoting to it. Naturally, the major portion of that space is taken up with descriptions of engineering material. This is the particular interest with which we are concerned. In a way, however, even from the point of view of a wider interest our treatment is not out of balance. Engineering has become the most important industry in the world and is at the back of every other industry. All modern transport is based on it and every type of manufacture looks to it for its tools. British engineering particularly in its textile branches, has ever benefited from the very definite movement which has set in towards every country manufacturing as much as possible by its own material. In the limit this policy is not an attractive one from our point of view, but in as far as the matter concerns foreign countries it is but an added reason for helping forward the development of our own Empire. In international competition the British manufacturer has not in the past been found wanting, and it may be trusted that he will receive much assistance for the stern competition of the future by the opportunity to study the best of modern practice in the Palaces of Engineering and Industry at Wembley.

ELECTRIC POWER SUPPLIES AND THE TELEPHONE SERVICES.

CROSS-TALK was a trouble frequently met with in the early days of telephone development and drew attention to the extraordinary sensitiveness of the then novel instrument, which will respond to the fraction of a microwatt. Means were soon found for eliminating the nuisance, but with the growth of long-distance electric power transmissions fresh difficulties have arisen, and no wholly satisfactory remedy for these has yet been devised. A highly interesting statement setting forth the serious nature of the disturbances thus produced was given by Mr. S. C. Bartholomew in a paper read at the meeting of the Institution of Electrical Engineers held on April 10 last. He also explained very fully the different ways in which power-transmission lines may interfere with "lines of communication," in which term are included both telegraphic and telephone wires. In fact, it is not merely the latter which are affected, but there have been, even in this country, several instances of telegraphic communication being completely stopped by the starting up of new power lines. This was notably the case with the famous 10,000-volt single-phase transmission from Deptford to the West End of London. It was originally intended to operate this with an earth return, but the immediate result was to put a stop to the use of certain telegraph lines to the Continent which paralleled the power lines for some distance along the railway. A return line to the power station had accordingly to be installed. With metallic return circuits Mr. Bartholomew states that the great majority of electric light and power systems in this country do not materially affect communication circuits, the more especially as underground cables are used here to a predominating degree, and where overhead lines are employed they generally follow cross-country routes, and are therefore not parallel to the main lines of telegraph and telephone wires. Nevertheless, there are occasional disturbances. Thus, when the Tulse Hill-Crystal Palace railway line was electrified, fire alarms, police circuits, and some telegraph lines were interfered with, and it was considered best to divert them from the track. Again, in 1920 telegraphic communication with Sweden was so hampered that the question of laying an additional submarine cable became a matter for serious consideration. Ultimately, however, the difficulty was traced to an unintended earth on the mains of the North-east Coast system of electric power distribution.

Abroad, matters have been much worse. In Sweden, after a careful inquiry, the Government have decided that it will be necessary to divert all communication lines from the electrified Stockholm–Gothenburg railway; and in California, where long-distance power transmission has made such an astonishing development, the difficulty in maintaining satisfactory service on the "communication lines" has been so serious that a commission was appointed to study the whole question exhaustively and to suggest remedies. In the latter regard success has not yet been attained, but the Commission has collected most valuable information, and at the same time has done good service in introducing a definite technical terminology. The difficulties in California are enhanced by the fact that the overhead lines not only work at enormous potentials, but to a large extent are parallel to the communication lines.

Power lines are classed by the Californian Commission according to whether their currents are "balanced," or have "residuals." In a balanced system the algebraic sum of the current in the several conductors is zero, and similarly if the voltages are balanced the algebraic sum of the voltages of the conductors measured relatively to the earth is also zero. A three-phase system with equal loads on each phase is a typical example of a balanced system, and with such a system interference with communication lines can be reduced to a minimum by "transposing" or "rotating" the power line conductors. Any residual current or voltage which is not balanced acts, however, on communication lines as would a single-phase system using the three conductors in parallel, and in that case interference will not be diminished by transposing the wires. It can, however, be reduced by transposing or "rotating" the communication lines. In a traction system with an uninsulated return the whole of the current and voltage would be classed by the Commission as residual.

So far as telephones are concerned the fundamental frequency of the supply is too low to affect the transmission of speech. It is the higher harmonics which give rise to trouble. An American writer, Mr. H. S. Osborne, has estimated that at 1,000 cycles per second the interference per volt is 1,000 times as great as with a frequency of 60 cycles, and 9,000 times as great as with 25 cycles.

It is obvious, therefore, that the wave form of the generators should approximate as closely as possible to the pure sine form. In practice this is never accurately realised, and the higher harmonics may include frequencies corresponding to those used in speech, and in such cases the interference may be serious. Even direct-current supplies may cause interference when obtained from a rotary converter by which ripples may be superimposed upon the nominally steady current or voltage. In the case of telegraph circuits the third harmonic is, Mr. Bartholomew states, a frequent source of trouble, and odd multiples of this harmonic may also appear and act in the same way. Much may be done by damping out this harmonic resonant by shunts placed across the phases.

Various attempts are being made to obtain a numerical measure of interference. The Post Office, as Mr. Bartholomew pointed out, classify their telephone circuits in terms of "miles of standard cable." By this is meant that the audibility on a given circuit is the same as if this were replaced by so many miles of this standard cable which has conductors weighing 20 lb. per mile and specified capacity and inductance. For local services a value of 30 miles of standard cable should, it is found, not be exceeded, whilst for long distance work the figure may be raised to 35. The cost of reducing the figure by even a single mile may, Mr. Bartholomew states, be very large. For example, on a 600-lb. aerial trunk circuit 200 miles long, an increase by 1 mile of standard cable would make it possible to use a 400-lb. circuit instead of the 600-lb. one. Methods are being tried for determining the amount of extraneous noise which can be tolerated in a circuit. A corresponding investigation has been made in America using an alternator to generate current, definite fractions of which can be shunted through a telephone so arranged that it can be coupled alternately to the noise generator and to the circuit, the noise in which is to be measured. Adjustment is made until the noise produced with the alternative couplings is considered to be the same. As a result of these experiments it had been suggested that in important long-distance circuits, the tolerable noise should not exceed that produced by 10 micro-amperes supplied from the noise-generating machine, the frequency of which is 240 cycles per second.

INTERNATIONAL CEMENT CONGRESS.

AN international congress, arranged by the Institution of Structural Engineers, was held at Olympia on Tuesday last, when members and delegates first visited the Building Exhibition, devoting the whole of the afternoon to the discussion of various questions relating to cement. In rather more than four hours the congress managed to consider something like fourteen papers, but as the programme of visits, &c., extended over Wednesday and Thursday as well, it was thought that other opportunities of less formal discussion would present themselves.

The chair was occupied by Mr. H. K. Bamber, who had acted as chairman of the organising committee, and who was supported by Major James Petrie, president of the Institution of Structural Engineers. All papers were taken as read.

Before the papers were actually taken Mr. H. D. Searles-Wood made a few introductory remarks. In these he drew attention to the proposal of the Ministry of Health to introduce bye-laws dealing with concrete block construction in which definite proportions of voids to solids were adopted. He objected to this matter being stereotyped, as it was dependent upon the method of construction. Following on general lines, Dr. C. H. Desch remarked that, while early developments of the cement industry had been made here and manufacture had been brought to a high level, we were indebted almost entirely to France, Germany and the United States for the scientific side of questions affecting the industry. The future depended entirely upon developments in this direction. Ciment Fondu was purely the result of scientific work. The congress was the first of its kind in the country and marked a step forward. It was surprising that at no university in the country was it possible for a student to secure scientific instruction on the subject of cement. Mr. J. Mitchell Moncrieff said that it should be impressed upon them that the congress was a cement congress and not a Portland cement congress. He thought they were on the threshold of most important events and something much greater than a restricted title would imply.

In dealing with the congress we propose to give merely brief summaries of the papers considered, indicating in each case the lines taken by the discussion, questions of space preventing any attempt at a verbatim report of the discussions which extended over so many hours. The first paper was one by Mr. A. S. Grunspan, which suggested that practical work with concrete would be facilitated by the adoption of a "modulus of density." This suggested modulus could be derived from the known percentage of voids in the coarse material, sand and cement, and from the amount of water used. The modulus might be obtained by dividing the granular volume of the cementitious material by the volume of voids to be filled by it. Mr. Grunspan worked out a number of typical examples

illustrative of the type of index obtained with various conditions of proportioning, and insisted upon the desirability of proper grading and uniform density, with frequent checks at the work on new consignments of aggregate. In discussing Mr. Grunspan's proposal Mr. A. Ingerslev said he would have preferred a modulus of density brought into relation with strength. Professor Duff Abrams in America had introduced a "modulus of fineness" which could be related to the crushing strength. Everybody wanted as dense a concrete as possible, but if too much fine material were used the results were poor. They had to strike the right mean between excess of fine and excess of voids. In connection with concrete ship construction a method of measuring the surface of the grains had been devised, in which the sand was immersed in petrol, subsequently drawn off into a bottle under slight vacuum. The method gave very consistent results, and it was possible to adopt an empirical formula giving results correct to within 5 per cent. Mr. H. J. Deane said that a committee of the Institution of Structural Engineers was engaged upon a tentative specification for crushing tests, with a view to securing greater uniformity of results. The proportion of voids might be obtained with petrol, as this would obviate the trouble due to air being held in the interstices by water. He thought if they could ensure uniform conditions of mixture, moisture and the state of the moulds, better results would follow.

Dr. Desch drew attention to the fact that the author had taken the volumes of cement and water separately and used the sum of these as the combined volume. That was hardly allowable. He considered the work of Prof. Abrams to be on sounder lines. Mr. Grunspan in defence of his method admitted that the combined volume was not the sum of the constituent volumes. The difference, however, was not determinable, and his method was put forward as a simple workable method. Mr. Bamber agreed that some simple method was wanted capable of being applied on works, in addition to laboratory methods.

A paper by Mr. F. Lindstead, on the "Measurement of Air Supply to Rotary Kilns," dealt with measurements by means of the pitot tube, and illustrated various applications. The author's object was to describe means of checking the quantity of excess air supplied so as to reduce losses due to this. Mr. Deane pointed out that though the author had said the ordinary U-tube was not suitable for small differential pressures, he had not indicated what form of tube should be used. The inclined tube could be used to read to $\frac{1}{100}$ in. quite easily. He had used such tubes with a slope of 1 in 20. He was further not satisfied that the mean velocity was always at 0·75 of the radius as the author suggested. With different velocities he thought its position would vary.

Following upon this, two papers were taken together. One was by Colonel H. Vaughan Kent on "Concrete Block Construction," and the second was by Major W. H. Smith on "Concrete Block Building." Colonel Kent's paper advocated a system of slab construction between columns, with an inner and outer skin. In this system, once the columns had been set up and correctly spaced, the panels could be run up very quickly and with a small expenditure of labour. The two skins were held together by ½-in. bolts. The columns carried the load, and between them only shallow concrete-filled trenches were necessary. Major Smith's paper consisted to a large extent of an argument to show that block construction had great advantages over slab construction and that a suitable form of block enabled a large variety of work to be done without the necessity of resorting to special arrangements. The author also advocated semi-wet or wet concrete as opposed to semi-dry, in which Col. Kent concurred. The discussion of these papers consisted of a rather amusing criticism of each paper by the author of the other, in which various points such as flexibility to meet architect's requirements, shock resistance, expansion and contraction, and the best disposal of material, were handled in turn. The statement by Lt.-Col. D. K. Edgar that blocks had to be laid by a bricklayer while slabs could be placed by semi-skilled labour was not accepted by Major Smith, and the discussion continued on this line for a time until the chairman said that that was a question which they could not hope to settle in that room.

The next paper was on "Silicate of Soda and Concrete." It was by Mr. L. A. Munro, and dealt with the behaviour of silicate of soda on concrete both in the form of surface treatment and of an ingredient in the mixture. The actual reactions were still obscure, but there was no doubt that the use of a high ratio solution of silicate of soda acted in some way on the lime to produce a firm jelly insoluble in water and capable of densifying the concrete treated. Surface treatment was suitable for floors, roads, &c. In abrasion tests, treated samples showed great superiority over untreated samples, and Mr. Munro exhibited blocks partly treated and partly untreated, which showed greatly increased wear for the latter. The machine in which the samples had been tested is to be seen at Wembley. The effect was more marked when fresh concrete was treated, but was also considerable on matured concrete.

Major Petrie remarked, with regard to concrete floors that the slippery surface acquired through wear could be avoided if the flour were carefully taken out of granite aggregate and clean granite chips used. Mr. Moncrieff said the paper seemed to be a little contradictory as silicate of soda was said to improve the strength of concrete in one case and reduce it in another. To this Mr. Munro replied that surface treatment actually increased the strength, but when used as an ingredient the strength was slightly reduced though the abrasion qualities were much improved. The solution must not be used too strong and the the process was cheap.

A paper by Mr. H. K. Bamber followed and dealt with "Some Disturbing Factors in Cement Setting." In this paper Mr. Bamber discussed such questions as the effect of grinding, storage, &c., upon the setting of cements. Mr. Bamber said that what actually happened in the setting of cement was so obscure that he had confined himself to making suggestions. Dr. Desch taking this up considered that the subject was not quite such an open question as the author implied. There was now a fair knowledge of the order in which the compounds formed, largely as a result of work of the Bureau of Standards of the United States. He thought that the storage effects noted were not, as the author suggested, always the effect of hydration, since some cements were known to change their setting time after storage in air-tight vessels. The change was probably due to some unstable constituents which altered for other reasons. Mr. Bamber said that the paper was largely brought forward to impress upon users the importance of proper storage, to which Major Petrie added that it was difficult to get men to take proper precautions for storage. If a position had proved satisfactory on one occasion, a similar one would be adopted another time regardless of the fact that changed conditions might render it quite unsuitable. Mr. Robinson said that there was now a good deal of information with regard to setting time, but they still knew little about quick hardening qualities. He suggested that the centenary of the invention of Portland cement might be celebrated by the founding of a chair at some university. The Institution of Structural Engineers might consult with the Institution of Civil Engineers on the subject.

The behaviour of Portland cement in sea water formed the subject for contribution by Mr. F. E. Wentworth-Shields, who, unfortunately, was not able to be present at the congress. In this paper Mr. Wentworth-Shields gave instances of failure and then dealt with the chemical effect of sea water upon cement, deterioration from physical causes and preventive chemical measures. The effect of impermeability was also considered, but the warning was given that no concrete can be absolutely impermeable. A standard test for impermeability was required. He did not think the addition of the special materials on the market improved the quality of concrete. In some cases strength was reduced.

Mr. Herluf Forchhammer of Denmark considered that harbour engineers were now satisfied that Portland cement could be safely employed in sea-water if used properly. It was essential to make it as impermeable as possible. Proportions of 1 : 2 gave a good mixture for mortar; but that was not enough. The whole concrete had to be made impermeable. A 1 : 1·5 : 4·5 mixture as given in the paper was not a dense mixture. It would be full of holes, and water would have easy access to the interior. The coarse aggregate, for a 1 : 2 mortar, must not exceed the volume of sand by more than 100 per cent. for mass concrete, and 60–70 per cent. for reinforced concrete. While a 1 : 1·5 : 4·5 mixture was not good, a 1 : 2 : 3 mixture might prove all right. The author had stated that the pouring of concrete under water should be avoided, but it was quite possible to do good work in this way with proper precautions. The Detroit tunnel was a case in point. The whole of the concrete for this had been placed in position about 40 ft. under water by means of pipes, and subsequent tests showed the concrete so placed to be stronger than concrete made in air, due, it was supposed, to increased density owing to the head under which it set. Mr. Mitchell Moncrieff agreed that good work could be done if proper care were taken, but the proportions would not be the same as if sea water were absent. The author had quoted one of his (Mr. Moncrieff's) experiences, of which he had cited two in a paper read before the International Navigation Congress of last year. The 1 : 1·5 : 4·5 mixture mentioned was not dense. When the dock was opened water appeared through 30 ft. of concrete. In the second experience he had given, a mixture of 1 : 2 : 4 had been used, due to a mistaken allowance for the coarse aggregate, which in that case had been broken stone, which did not pack so closely as gravel. The point was that there must be a full supply of mortar. The difference in actual cost between a 1 : 2 : 3 mixture and one of the proportions of 1 : 2 : 4 was so small compared with the troubles which might arise through effecting economy in this direction, as not to be worth considering. The question should be as to how a small saving of the kind would affect the work as a whole. He considered that blast furnace slag should only be introduced as an aggregate with a great deal of caution. Its adoption might have very dangerous effects.

Mr. H. J. Deane thought that we were so accustomed to stating some accepted mixture that it was often thought that this was all that was necessary. However, he thought the better way to get dense concrete was first to procure the aggregate and then work from that to the mixture. That would prove to be a better manner of working than keeping to stereotyped proportions. Further, the composition of the aggregate must be examined. Bearing upon what Mr. Moncrieff had said regarding slag, Mr. Deane quoted an instance in which tiling laid on cement rendering had bulged and fallen down. On being replaced the same thing had happened again, and on investigation it was found that water containing sulphuric acid had percolated through the bricks on which the facing of tiles had been laid, while the bricks themselves (ordinary Flettons) were shown to contain sulphur and to be bad for any position where moisture was present. The discussion was concluded by Colonel Vaughan Kent, who said he was surprised that no mention was made in the paper of Super-cement, which he believed came as near to being impermeable as it was possible to get.

(To be continued.)

LITERATURE.

Merchant Ship Types: A Survey of the Various Units Engaged in the Water Transport of People and Merchandise. By A. C. HARDY, B.Sc. London: Chapman and Hall, Limited. [Price 15*s.* net.]

THE work with the above title seems to have been prepared principally for the uninitiated, as will be gathered from Dr. Welsh's introductory notes, and it might be argued that the writer has covered too wide a field for the tastes of "the man on shore" or the university student. Even the layman of to-day prefers rather to concentrate on one particular phase of a subject than to endeavour to grasp the whole field of any activity from a single volume. This is as it should be, and particularly so when one wishes to understand, even generally, the extreme intricacies of ship design and management.

Although such a work as this is uncommon, there are precedents which have been prepared to suit the general public, such as Williamson's "*Clyde River Steamers*," a work which obtained great popularity simply because it was entirely devoid of technicality, and we think the author would have gained more favour for the great amount of work he has expended had he confined himself severely to either entirely lay or entirely technical treatment of his subject. Nevertheless, there are chapters in the work which will be of general interest to all, particularly that dealing with the history of the oil-tanker, which is very complete.

Although the volume is not of a suggestive nature so far as future progress is concerned, it does describe our present difficulties, and the illustrations and drawings will be useful to all, including those of experience who may not have had time systematically to collect and file the vast amount of information which has appeared in the technical press. The grouping of the illustrations enables one to compare the appearances of the ships of different nationalities, and there will be general agreement regarding the author's views as to the ungainly appearance of those designed by our American cousins. It might have been added that the Germans had erred to almost an equal extent in connection with their latest production—the "Albert Ballin." There does not appear to be any advantage obtainable from the adoption of plumb and stumpy masts and funnels in vessels of this class, and it will not be denied that they cut poor figures alongside our elegant Cunarders or Empress liners.

Some comment might be made upon the definitions and advantages of certain designs as stated by the author; for instance, it might be misleading to claim that the topside tanks in special types of cargo carriers "give extra reserve buoyancy to a ship when empty," for it is thought such tanks would not increase the buoyancy provided by the freeboard. Again, he does not seem to express the generally accepted meaning for bulk cargoes when he states that "a bulk cargo is one which stows densely and puts a ship down to her loadline with her hold only half full." We are under the impression that this definition would be applicable to a deadweight cargo, and that a bulk cargo is one which would occupy all the stowage space without putting the vessel down to her marks. Some comment might also be made upon the explanation regarding the method of measuring tonnage. It is stated that the net tonnage is the gross, minus the actual crew space and the machinery space, except when the latter lies between 13 per cent. and 20 per cent. of the gross. Since this is a special paragraph bearing upon tonnage, it would have been correct to have stated that the law allows a reduction of $1\frac{3}{4}$ times the actual volume of machinery spaces for cases outside the limits named.

A Treatise on Electro-Metallurgy. By W. G. McMILLAN. Revised by W. R. COOPER, M.A., B.Sc. Fourth Edition, revised and enlarged. London: Griffin and Co., Limited. [Price 21*s.* net.]

THE application of electricity to metallurgy, although of comparatively recent date, has been responsible for many far-reaching changes. Aluminium, for instance, which for many years was little more than a chemical curiosity, is now, thanks to electrochemical processes of extraction, used in large quantities by engineers. Again, electrolytic copper has become quite a common material in non-ferrous foundry practice. It is also well known that the high degree of purity and the constant average composition of the various ferro-alloys supplied to steel manufacturers are, in a great measure, due to the fact that they are produced by electro-thermal means. The above are three outstanding examples, typical perhaps of three distinct metallurgical processes involving electrical energy; they are, incidentally, indicative of the extent and scope of the electro-metallurgical industry.

Electro-metallurgy is, according to the authors, the term applied to all classes of work which necessitate the deposition of metals by means of the electric current. This, although quite a good definition, hardly goes far enough, as it does not include electro-thermal processes in which electricity is used simply as the source of heat. After giving a brief historical sketch of the subject under consideration and touching upon the rapid progress made in recent years, the authors devote some space to theoretical electricity and elementary physical chemistry. This section is intended to help the novice to understand the principal laws underlying the science of electro-metallurgy, and is meant to be used as a guide for further study.

Nearly half the book is devoted to electro-plating in all its forms, and the various methods of procedure are given in great detail. Mechanical difficulties as well as purely electrical problems are thoroughly discussed. The ground covered is very wide, such subjects as electrotyping and the application of electrolysis to the reproduction of printing surfaces generally are given a good deal of consideration. A very complete and concise glossary of substances commonly employed in electrolytic processes will be found very useful.

The description of the processes involved in the electro-refining of crude copper is well set out, as are the methods of obtaining pure aluminium from the electrolysis of fused ores; all modern developments are included as far as possible. In cases in which the electro-smelting of various metallic ores has been operated on a commercial scale, the authors compare the ordinary metallurgical processes and carefully weigh the advantages and disadvantages of the newer methods of production. All the various types of electric furnaces now in use in connection with the steel industry are fully dealt with, and, generally speaking, the authors would seem to incline to the opinion that, rather than supersede the older crucible and open-hearth furnaces, the electric furnace should be used in conjunction with them.

Throughout the book the authors have shown themselves to be thoroughly practical men, fully alive to difficulties and costs of working. In some respects the work is encyclopædic in character, and while in some chapters one finds set out facts of quite elementary order, other sections are devoted to the most modern aspects of theoretical electricity. A manufacturer who has momentarily forgotten what is meant by the term "coulomb," for example, will find this aptly defined. He will also find precise instructions on how to clean greasy metal prior to plating, how to fold a filter paper, and how and when to administer antidotes in cases of accidental poisoning. On the other hand, many readers will welcome the chapter on modern theories of electrolysis, in which are described, in well-chosen language, such complex subjects as osmotic pressures, ionic velocities, and heats of ionisation.

Books of this type have one drawback: the ground covered is so wide that few readers (with the exception of metallurgical students) will be interested in more than one particular portion of the subject-matter. A Héroult steel furnaceman, for example, is not likely to read the chapters devoted to electro-plating and typing, whilst a silver-plater, in the majority of cases, will leave those pages devoted to electro-smelting quite untouched. We are living in the age of the specialist, and this becomes more and more apparent as time goes on. The book is, nevertheless, never tedious: the authors' statements are always strictly relevant; they keep each subject well in view, and thus retain the reader's interest.

BOOKS RECEIVED.

United States Geological Survey. Mineral Resources of the United States. I: 17. *Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in* 1922. *Mines Report.* By C. W. HENDERSON. I:18. *Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in* 1922. *Mines Report.* By C. N. GERRY. II:24. *Mineral Waters in* 1922. By W. D. COLLINS. II:25. *Abrasive Materials in* 1922. By L. M. BEACH and A. T. COONS. II:26. *Cement in* 1922. By E. F. BURCHARD and B. N. BAYLEY. Washington: Government Printing Office.

Taschenbuch für den Maschinenbau. Vols. I and II. By H. Dubbel. Fourth edition, revised and enlarged. Berlin: Julius Springer. [Price 4·30 dols.]

Die Physikalischen und Chemischen Grundlagen des Eisenhuttenwesens. By WALTER MATHESIUS. Second revised edition. Liupzig: Otto Spamer. [Price 27 gold marks.]

Theory and Practice of Mine Ventilation. A Textbook for Students. By THOMAS BRYSON, M.I.Min.E. London: Edward Arnold and Co. [Price 8*s.* 6*d.* net.]

"*Broadcast Listeners*" *Year Book*, 1924. London: Radio Press, Limited. [Price 1*s.* 6*d.* net.]

LETTERS TO THE EDITOR.

"THE COMPARISON OF INTERNAL-COMBUSTION ENGINE EFFICIENCIES."

TO THE EDITOR OF ENGINEERING.

SIR,—During the recent discussion at the Institution of Civil Engineers on "Efficiency Standards for Internal-combustion Engines," considerable stress was laid by various speakers upon the expressions for the specific heat of gaseous mixtures attributed to Stodola. I do not think, however, that Stodola ever published these expressions as they stand. The figures given agree with those arrived at by me by a process of deduction from an article of Stodola's in the *Zeitschrift des Vereines Deutscher Ingenieure*, June 22, 1912, and which I used in an article on the "Limits of Gas Engine Efficiency," in ENGINEERING, December 18, 1914. It seems probable that later writers who quote the specific heat formulæ as Stodola's have really obtained the figures directly or indirectly from the ENGINEERING article.

The degree in which they are due to Stodola is only limited and is fully explained in that article. The coefficients of the second and third terms are based on figures chosen as typical from among *several* values given by Stodola, and, further, all the coefficients had to be converted into the form now quoted by means of an assumption as to the mean density of the probable typical mixture.

The formulæ in question have no doubt been regarded by the Committee on Heat Engine Trials and by others as having an authority to which they are not entitled. I understand—though at present I have not been able to verify it—that Stodola subsequently has modified the specific heat values he used in 1912. In any case it is important that the figures under consideration should be traced back to their original source before judgment upon their adoption or otherwise be pronounced.

Yours faithfully,
T. B. MORLEY.

Messrs. Galloways, Limited, Manchester, April 17.

"THE CALCULUS OF OBSERVATIONS."

TO THE EDITOR OF ENGINEERING.

SIR,—In your review in your current issue of Professor Whittaker's book—"The Calculus of Observations"—you refer to a diagram for solving equations of the form $x^2 + ax + b = 0$, and the description given suggests a graphical solution of the term $\pm \sqrt{(a^2 - 4b)}$.

It may not be generally known that equations of this form can be solved upon the slide-rule. About five or six years ago I published this method in the *American Machinist* and gave examples of its application to problems arising in engineering practice which were illustrated by photographs of the actual settings on the rule.

Noting your earlier remarks upon Dr. Whittaker's exclusion of the slide-rule as a tool for use upon problems in his work, I conclude that the diagram is designed to give a greater degree of accuracy than that obtainable upon a 10-in. slide-rule. It has not yet been my privilege to see the book and thus to ascertain whether the principle of solution by factors is discussed. The author will be aware of the manner in which the slide-rule can be adapted for solving, upon this principle, any equation of the form given; but he is probably unaware of my having described the mechanical method and enunciated simple laws for determining the signs of the roots.

Yours faithfully,
MARK JENNINGS, A.M.I.Mech.E.

122, Queen's Road, Bury St. Edmund's,
April 19, 1924.

HEAT TREATMENT OF METALS AND ALLOYS.—A course of instruction in this subject will be given on Wednesday evenings at the Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C.3, by Dr. O. F. Hudson, during the Summer Term, commencing on Wednesday, April 30, at 7 p.m. The fee is 10*s.* for residents in the administrative County of London and in the County of Middlesex.

PERSONAL.—The new address in Leeds of The Consolidated Pneumatic Tool Company, Limited, is 67, St. Pauls-street.—The Council of the Institution of Production Engineers announce the resignation of their Secretary, Mr. A. T. Davey, who is taking up a position with Messrs. W. H. Allen and Sons, Limited, Bedford. The honorary secretaryship will in future be filled by Mr. E. D. Ball, 20, Lushington Road, Harlesden, N.W.10.—The new London address of The British Reinforced Concrete Engineering Company, Limited, is King's Building, Smith Square, Westminster, S.W. 1, as announced on page 471 *ante*. Their head office remains at 1, Dickinson-street, Manchester.

FURTHER EXPERIMENTAL WORK ON DIESEL ENGINES.*

By Engineer-Commander R. BEEMAN, C.M.G., R.N., Engineer-in-Chief's Department, Admiralty.

A PAPER entitled "Some Experimental Work on Diesel Engines," presented by Engineer-Commander C. J. Hawkes, R.N., at the Summer Meeting of this institution in 1920, described some of the work carried out at the Admiralty Engineering Laboratory up to that date. The investigations then discussed indicated also the trend of the research instituted to develop the oil engine for the requirements particular to the naval service. The purpose of the present paper is to describe some of the further experimental work that can be made public. It is not possible, in any case, to cover, within the compass of a paper, the range of the work undertaken by the Laboratory, and choice has been confined to such items as appear likely to be of general interest to those concerned in oil-engine development elsewhere.

In weighing the possibilities of the application of Diesel engines for the propelling machinery of surface war vessels, prominence must be given to two particular features which have attended the development of the modern high-speed war vessel. One is the economy in machinery weight possible in suitably designed steam machinery installations comprising oil-fired small tube water-tube boilers and geared turbines. Particulars of representative vessels so fitted are indicated in Table I, columns 1 to 4. The second feature is the high power transmitted through a single propeller shaft, which ranges up through the various classes of vessels from 13,500 shaft horse-power in the T.B.D. class to 36,000 in the battle cruiser class. There is no reason to suppose that the demands on machinery in any future warships will be less severe than in the past, and these two particular features indicate accordingly the broad design requirements to which the Diesel engine design must conform. Their fulfilment entails a marked decrease in weight as compared with the designs being successfully employed in the mercantile marine to-day, coupled with a marked increase in the shaft horse-power that can be passed to a single propeller shaft.

The question of the weight of the machinery cannot, of course, be separated from the question of the fuel economy of the machinery. It is hardly possible to trace in the general case the precise effect on the design and performance of a warship, of machinery weight *versus* fuel weight. Moreover, the matter is complicated by uncertainties as to the precise nature of the service the ship may be called upon to perform and by other considerations. It is proposed, however, in order to obtain an approximate basis weight to which the oil-engine design should conform, to assume that the lower fuel consumption would permit of an increased weight of machinery, given by the following relation :—

Weight of oil-engine installation = Weight of existing steam installation + ¼ weight of fuel carried in existing steam installation.

The basis of this somewhat arbitrary and debatable relation is that the consumption of the oil engine will average one-half of that of the steam plant, and that the displacement of the vessel is the same in each case under average sea-going conditions ; that is, when one-half of the fuel is expended.

On these premises, the permissible weight of the complete oil-engine installation per shaft horse-power would be as shown in column 5, Table I, and columns 3, 4 and 5 represent the conditions to be fulfilled by the oil-engine alternative. The lowest power on the single shaft is 13,500. In no case has this power been developed on a single shaft in Diesel engine practice, and in the isolated cases where it has been approached experimentally the speed of revolution was relatively low ; in such designs the weight would be considerable in comparison with Naval practice. In fact, in the submarine service where great efforts are necessary to cut down the weight of machinery, the weight of the highest powered Diesel engine, running at about 400 r.p.m., is 50 lb. per shaft horse-power for the engine alone, and the weight of the complete surface propelling installation is 85 lb. per shaft horse-power. In these modern warship designs given in Table I, therefore, the power required is beyond that which the present developments of the oil engine would justify being employed on a single shaft, and in those cases where the power appears to be within the possibly attainable reach of the oil engine, the weight restrictions are prohibitive.

The battleship class is not represented in this list as no vessel having steam machinery of the modern type referred to is yet on service. This class of vessel, in which the speed is relatively low, offers a more promising field of application than those given in the table, in so far as the machinery weight can be allotted on a rather more generous scale and the fuel capacity is customarily rather higher in proportion to the machinery weight than in other vessels. Such a design, supposing the ship design permitted the power to be divided over four shafts, would require oil engines capable of developing not less than 10,000 shaft horse-power per shaft for a total machinery weight (corresponding to those given in column 5) of 130 to 150 lb. per shaft horse-power if it is to compete with the steam engine. These questions of weight and power developed are very closely related, as will appear from further examination of the problem.

On the grounds of restricted weight and head-room the naval engine is necessarily a high-speed engine of comparatively short stroke, i.e., running at a high piston speed and at a high speed of revolution. Further, from the point of view of attaining a maximum power output, it would be required to operate with high mean pressure in the cylinder without unduly high maximum pressure, which governs to a considerable extent the scantlings of the important parts and so influences the weight.

The use of high mean pressures tends to set a limit to the diameter of the cylinder and so to the power developed. This follows directly from the high temperature of combustion and from the fact that as the diameter is increased the extent of the heat receiving surface becomes less in proportion to the heat transmitted from the burning gas. Thus it follows that the attainment of high mean pressures in cylinders of large diameter imposes a higher heat stress than in small cylinders, and this is further aggravated by the necessity of giving heavier scantlings to secure the strength required to withstand the higher maximum pressure. This influence can be countered to some extent by special measures in respect to shielding and cooling, and the large designs are probably better suited to such devices, but those designs employing high mean pressures are nevertheless less reliable in the nature of things than those that are more moderately rated. In this respect the two-stroke engines are evidently more severely heat stressed, for the same developed mean pressures, than the four-stroke engine ; but the change of type from two stroke, single acting to two stroke, double acting, need not be attended by any appreciable augmentation in heat stress in the case of the more highly stressed members.

TABLE I.

—	1 * Weight per S.H.P. on Trial. Steam-Machinery installation	2 Number of Shafts.	3 Designed S.H.P. per Shaft.	4 Revolutions per Minute.	5 Permissible Weight per designed S.H.P. Oil-engine Installation.
Battle Cruiser..	81	4	36,000	210	100
Cruiser.. ..	65	4	16,000	400	85
Light cruiser ..	54	2	20,000	275	69
Flotilla leader..	35	2	20,000	350	42
T.B.D... ..	33	2	13,500	360	40

* This weight comprises the main and auxiliary machinery complete in running condition. It includes the water in boilers, feed tanks, condensers, &c., and the oil in lubricating systems ; also machinery spares, ship pumping machinery in main machinery spaces, workshop machinery, distilling plant, air compressing plant and steering engines.

The question of obtaining efficient combustion when using high mean pressures in high-speed, short-stroke engines is also of considerable significance. Actually, the time available for injection and combustion may be as little as from 1/25th to 1/40th of a second in a typical Naval design, and the difficulties of ensuring satisfactory combustion increase as the rate of combustion is raised. These complicated relations between weight, space, and power output combine to set a limit to the power obtainable from a *single cylinder*, according to the type of engine, if reasonably good reliability is to be realised without undesirable complication. The attainment of the high aggregate powers indicated will therefore lead to undue multiplicity of cylinders in any case, this disability, however, being lessened as the engine type is advanced. This consideration, coupled with the marked handicap in weight from which the single-acting Diesel engine can hardly fail to suffer in comparison with the steam installations, leads to the conclusion, according to the experience at present available, that the greatest promise, with an application to surface war vessels in view, rests with the double-acting, two-cycle type. The comparison between the power output obtained on a given space from oil engines of the various types as indicated in the 1920 paper (Table VI)* stands.

The well appreciated mechanical difficulties, and in particular the attainment of adequate longitudinal rigidity of the engine on a reasonable allocation of weight for engine structure, render it imprudent to attempt to couple at most more than eight large cylinders on a single crankshaft. On this basis, it does not appear possible with our present knowledge to exceed about 10,000 brake horse-power, from a single high-speed engine design for naval work, without considerable reduction in the standard of reliability and durability. The possibilities of a design within this limit remain to be explored in a unit cylinder design at the Laboratory, and the practical work will be commenced shortly, with a full appreciation of the difficulties to be surmounted before such a design can be regarded as the basis for a trustworthy and reliable engine for service afloat.

The problem will not be solved entirely with the production of a reliable unit, developing the required high power and falling within the desired weight. Others remain, and of these particular reference may be made to the necessity for flexibility, which is of such great importance in the Naval service. The naval engine must be capable of running steadily at the very low powers and reduced speeds, corresponding to cruising conditions. It must be responsive to rapid changes of speed and must settle down steadily and quickly to any desired intermediate speed. These requirements bring with them special problems from the combustion and control aspects which are matters for special investigation and development as an essential part of the main problem.

An engine of 10,000 S.H.P. has been indicated as a possibility within range. Notwithstanding the relatively high power of this tentative unit, in comparison with those in use in the mercantile marine to-day, it will be seen from Table I that it still falls outside of the stipulated requirements in respect to the power transmitted to a single shaft for the classes of vessels there given.

Alternatives exist, however, by means of which such a high-speed engine may be used for a high-powered installation ; such, for example, as one of a number of power generators in an electrical transmission design, or again, as one of a number of power units geared to the propeller shaft through some form of flexible transmission. The weight of the additional fittings would certainly prohibit these alternatives in the Naval service, and in any case the number of power cylinders remains relatively high, so that the maintenance and running liabilities of such a highly taxed design may be expected to be disproportionately high in relation to a steam plant.

It is probable that a direct-driven design comprising 10,000 h.p. engines of the double-acting, two-stroke type would fall within the limit of weight mentioned for the battleship type of vessel, viz., 150 lb. per shaft horse-power, although the higher propeller revolutions would lead to some loss in propulsive efficiency.

This weight may appear excessively high for such a design, having in view the figures given for the submarine engine (viz., 85 lb. per shaft horse-power) but it includes provision, according to Admiralty convention, for certain ship and fighting appliances apart from the purely propelling machinery. Also, it provides at source for the power to actuate all the ship's services and fighting appliances. The provision of the alternative form of power to replace the steam now used for these services would impose a disproportionate tax upon such an installation as a battleship in which the propelling power is relatively low and the fighting and ship's appliances are relatively extensive.

It appears, when due consideration is paid to these matters, and notwithstanding a very considerable saving in the weight of the oil engine as compared with general mercantile practice, that the weight required for the complete installation (when duly credited for the lower fuel consumption of the prime movers) will not be greatly different from that of the steam plant. Therefore, so far as the speed of the vessel is concerned, there is likely to be no appreciable change because the displacement, by hypothesis, remains sensibly the same.

Whether it will be possible to develop a reliable design yielding the desired qualities peculiar to the Naval service must remain at present a matter for conjecture rather than for a definite opinion. All experience, however, goes to show that progress in the development of the oil engine is slow. Each advance is attended by difficulties disproportionately great in relation to the progress made, and the precise difficulties cannot always be predicted at the design stage. They become evident only when full-scale trials are made and their solution is usually a tedious step-by-step process in which the several variables leading to the difficulties are eliminated one by one, so far as is possible. This is essentially a matter for laboratory as distinct from workshop methods, and the problem calls not only for engineering skill of a high order but for a thorough and up-to-date understanding of the metallurgical aspects.

(To be continued.)

* Abstract of paper read at the Spring Meeting of the Institution of Naval Architects, April 11, 1924.

* See ENGINEERING, vol. cx, page 131.

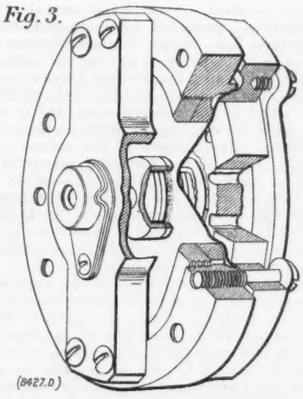
THE PUBLIC ADDRESS SYSTEM AT THE BRITISH EMPIRE EXHIBITION.

THE WESTERN ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON.

FIG. 1.

FIG. 2.

Fig. 3.



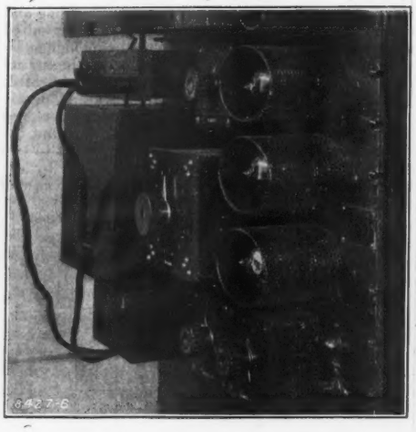


FIG. 4.

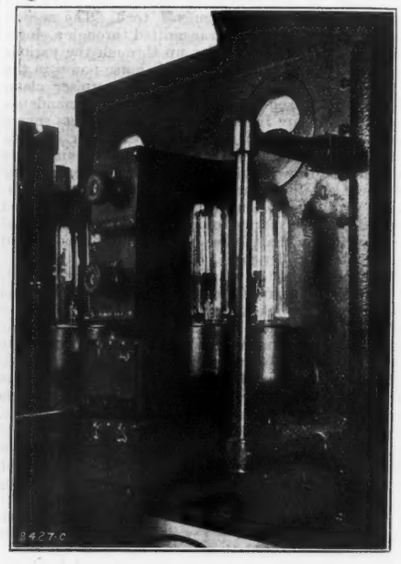


FIG. 5.

THE PUBLIC ADDRESS SYSTEM AT THE BRITISH EMPIRE EXHIBITION.

OF the many important scientific attainments rendered possible by the properties of the three-electrode thermionic valve, one of particular interest at the present moment is its use for magnifying the sound of the human voice to enable a speaker, without particular effort, to be heard by an audience of many hundreds of thousands of persons simultaneously. Formerly the magnitude of an audience, either in a building or out of doors, was limited by the power of the human voice to about 5,000 persons, but the instrument above referred to has enabled speeches to be heard by 125,000 people in one group, as well as by large audiences congregated in cities many hundreds of miles distant from that in which the actual speech was made. Apparatus for this purpose has been developed by the Western Electric Company, Limited, Connaught House, Aldwych, W.C. 2, and has been employed on numerous occasions in the United States. The system, known as the public-address system, has also been employed in this country, its most important application on this side of the Atlantic having been in connection with the opening ceremony of the British Empire Exhibition on Wednesday last. On this occasion, His Majesty's address, delivered in his normal voice in a pavilion erected near one end of the stadium, was distinctly heard by an audience of 120,000 persons in the stadium alone, and as a number of groups of loud-speaking receivers were installed in the amusements park, the speech was audible throughout practically the whole of the exhibition grounds. The speech, and other items of the ceremony, were also transmitted by land line to the London station of the British Broadcasting Company, whence they were broadcast by wireless telephony and also transmitted by land line telephony to the other broadcasting stations in different parts of the country. They could thus be heard by His Majesty's subjects in all parts of the British Isles, and probably by many of them in the Overseas Dominions.

In view of the historic interest of the occasion we propose to give a brief account of the apparatus employed for rendering the speech audible over the whole of the stadium, which measures roughly 900 ft. in length by 600 ft. in breadth, although a full discussion of the many interesting electrical and acoustical problems involved will not be possible in the space at our disposal. The function of the apparatus is to magnify the weak current fluctuations produced in the electrical circuit of a microphone by the action of the sound waves on the diaphragm, so that the magnified current fluctuations will have sufficient strength to operate the diaphragms of a number of large loud-speaking telephone receivers, which thus reproduce the sound waves on a greatly amplified scale. The main technical difficulty of the problem is, of course, to obtain the necessary degree of amplification with the minimum of distortion of the original wave form, but that this difficulty has been practically overcome was evident from the fact that the well-known characteristics of His Majesty's voice were easily recognisable in the speech as reproduced at Wembley on Wednesday last.

The apparatus, which was in duplicate throughout in order to avoid any possibility of failure, comprised a microphone suspended from the roof of the Royal Pavilion and connected to valve amplifiers situated in a control room below the platform. The magnified currents from the amplifiers were conveyed through a control frame to seven loud-speaking telephone receivers, or projectors as they are called, located in the roof of the pavilion. The form of microphone employed is shown in Figs. 1 and 2 on this page, and its essential parts are illustrated diagrammatically in Fig. 3. For this particular service it is necessary for the microphone to respond equally to speech frequencies ranging from 200 per second to about 6,000 per second, and, to avoid resonance at any intermediate frequency, the natural period of the diaphragm must be higher than any of the speech frequencies employed. By damping, the natural frequency of the diaphragm is suppressed, so that it is rendered truly aperiodic, but the elimination of resonance effects in this way greatly reduces the magnitude of the current fluctuations produced.

In the Western Electric Company's microphone, the diaphragm is a disc of Duralumin, less than 0·002 in. in thickness, stretched between a pair of steel supporting rings, as shown in Fig. 3; it will be understood, of course, that the thickness of the diaphragm has been greatly exaggerated in the illustration. On each side of the diaphragm is a small chamber containing special carbon granules, the pressure on one group of granules being increased and that on the other group being reduced by the movement of the diaphragm. The employment of two groups of granules in this way enables the asymmetric distortion inherent in the simple carbon microphone to be eliminated by a process of neutralisation. The necessary damping is obtained by placing a thick perforated plate behind and in close proximity to the diaphragm, as indicated in Fig. 3, the damping effect arising from the movement of the air in the holes set up by the rapid vibration of the diaphragm. The complete microphone, as shown in Fig. 2, is suspended by helical springs in a wire-cage housing, this method of mounting serving to protect the microphone from the effects of external vibrations.

The diaphragm of the microphone is connected through a potentiometer, supplied by a 12-volt battery, to the middle point of the primary winding of a transformer, the two sets of carbon granules being connected to the opposite ends of the same winding. The secondary of this transformer is connected between the grid and filament of the first valve of a three-valve reactance-capacity coupled speech amplifier, which we illustrate in Fig. 4. The three valves used are of the dull-emitter type, the filament current being supplied from a 12-volt battery while the plates are fed with direct current at a pressure of 350 volts from a motor-driven generator. In the case of the first two valves, the grids are maintained at the proper potential to give distortionless amplification by utilising the drop along resistances included in the filament circuits, but for the third valve small grid cells are employed. Means are provided for regulating the amount of amplification obtained, but, as a maximum, the power input, which is of the order of 10^{-8} watt, can be increased to 0·3 watt without distortion. The output from the speech amplifier is passed through a transformer to a single-stage power amplifier, illustrated in Fig. 5. In this amplifier four dull-emitter valves, connected in parallel, are employed, the filaments being lighted from a 12-volt battery and the plates supplied with direct current at 750 volts from a generator. The output from this amplifier may amount to 40 watts, so that the total maximum power

amplification available reaches the remarkable figure 40×10^8.

From the output transformer of the power amplifier the telephone currents, magnified as above described, are led to a control panel uniform in dimensions with the amplifier panels. The object of the control panel is to enable the operator in charge of the apparatus to regulate the volume of sound produced by each of the loud-speaking receivers, in accordance with requirements. The equipment of the panel consists essentially of an auto-transformer connected across the secondary of the output transformer of the power amplifier. Tappings from the auto-transformer windings are connected to the contacts of eight dial switches controlling the circuits of the seven loud-speaking receivers mounted on the top of the pavilion, and of an additional loud speaker located in the control-room to enable the operator to judge the quality of the speech and adjust it if necessary. The movement of the dial switches connects the loud speakers across different numbers of turns of the auto-transformer, and thus provides the requisite means for regulating the volume of sound produced. A key placed on the control panel close to each of the dial switches enables any of the loud speakers to be cut out, and a master key is also provided to enable them all to be put out of action simultaneously. Above the control panel is mounted a volume indicator to show the amount of energy being supplied to the loud speakers collectively. It consists of a valve detector connected across the secondary of the output transformer of the power amplifier, the current rectified by the valve being measured in a sensitive moving-coil milliammeter, the deflection of which is a measure of the output from the amplifier. A tapping was also provided from the power-amplifier transformer leading through another transformer to the land line connected with the London Broadcasting Station to enable the speeches to be broadcast by wireless telephony, as mentioned above, but the Broadcasting Company, we understand, also installed their own microphones for this purpose.

The loud-speaking receivers are of the balanced armature type, each being designed to utilise up to 40 watts of energy without introducing distortion in the sounds reproduced. The principle upon which the receivers function is as follows: A light soft-iron armature, pivoted at its centre, is mounted between the poles of a permanent magnet and connected at one end to the diaphragm. U-shaped pole pieces attached to the inner face of each pole of the permanent magnet are arranged so that the ends of the armature are located in the air gaps between the vertical legs of the U's. Surrounding the central portion of the armature, but not in contact with it, is a coil carrying the amplified telephone currents received from the control panel and the changes in the magnitude and direction of the currents cause corresponding variations in the magnetic flux in the armature. For any particular direction of the flux in the armature, the latter is attracted by one of the pole pieces at one end and repelled by the other pole piece at the same end. The effect is exactly duplicated, in opposite directions, at the other end of the armature, and the latter is consequently continually oscillated about its pivot, as the current in the coil changes in magnitude and sign. The oscillating motion of the armature is communicated, by the mechanical connection above mentioned, to the diaphragm, which is thus caused to vibrate in a manner corresponding to the fluctuations in the speech current. The diaphragm, it should be mentioned, is formed of impregnated cloth, and is corrugated to permit of vibrations of comparatively large amplitude. The working parts of the receiver are provided with a metal cover and are enclosed in a cast-iron case for protection, while the space on one side of the diaphragm is connected to a tapered wooden horn 10 ft. 6 in. in length and of rectangular cross section. The sides of the horn are stiffened by external frames at intervals, in order to prevent resonance.

It will be evident from the above general description of the apparatus employed that very great care and forethought have been exercised in developing the system, and although the absolute perfection sometimes demanded in acoustical matters has perhaps not yet been attained, the results achieved at Wembley were certainly sufficient to demonstrate the fact that the many problems involved have been solved to an extent which renders the apparatus of real utility on such occasions.

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION.—The fourth annual report for the year ending December 31, 1923, has now been issued by this Association. It gives an account of the work carried out on a large number of non-ferrous metals and alloys, and states that there were on that date over 20 separate investigations in hand, compared with ten at the end of the previous year. The membership had advanced to 118, and the income for the year was 10,766*l.*, or double that it amounted to two years ago.

THE DEVELOPMENT OF THE LONDON UNDERGROUND RAILWAYS.

AN important stage in the improvement of the underground electric railways of London was reached when the junction at Camden Town was put into service and the line from Moorgate to Euston was reopened after widening on Sunday last. The first part of the work was completed in November 19 of last year, when the Golders Green line was extended to Hendon. Other work now in progress comprises the continuance of this line to Edgware and also the extension of the City and South London Railway from Clapham Common to Morden, while a connecting link is being made from Kennington on that system to Charing Cross on the Hampstead line.

The recent work on the City and South London Railway and the junction to the Hampstead system was carried out to permit the use of the standard rolling stock adopted for the other lines and to make inter-communication possible. The City and South London is the oldest tube railway in the World. When the system was absorbed into the group of the Underground Electric Railways plans were immediately prepared for its widening and interconnection with the other lines. Parliamentary powers were obtained in 1913, but the conditions operative during and after the European War prevented the commencement of the work until August, 1922. At that time there were junctions in existence at Camden Town between the lines to and from Hampstead and those to and from Highgate. Connections had to be made between both of these lines and the City and South London, and, because of the density of traffic which will result from the new facilities, it was decided that the existing lines could not be crossed on the level. Flying or burrowing junctions were adopted to surmount the difficulty, with the result that the two tube tunnels south of Camden Town had to be increased to six. The two stations at Euston lie at right angles to each other, but at different levels. The new railway is therefore carried from a point 245 ft. west of Euston platform on the City and South London Railway in two tubes passing under the Hampstead Railway and then in a diagonal direction by a curve of approximately 1,050 ft. in length to the six tunnels. In the straight parts the diameter of the tubes is the standard one of 11 ft. 8¼ in., on medium curves of from 20 to 10 chains, the diameter is 12 ft. and for more severe curves it is 12 ft. 6 in. Where the lines converge or diverge the tunnel is stepped up to 25 ft.

Three shafts were sunk for the work, two at Morning ton Crescent, 3,180 ft. from Euston, between the existing tunnels and the Hampstead tube, and the third, in Ampthill Square, 1,500 ft. from Euston, where the tubes are at the same level. Tunnelling operations had generally to be performed in mottled clay and in London clay, but at a point about 100 ft. from the Ampthill shaft a pocket of grey sand and water was encountered. This extended about 100 yards, and in this section the tunnelling had to be done under compressed air. The most intricate work was performed at the junctions at the Camden Town end, where work was confined to periods of from four to five hours each night, while the traffic was suspended on the Hampstead and Highgate Railway. This entailed removing the concrete from under the rails of the existing tubes, the replacement of the segments and the fitting of steel joists under the tracks.

The total length of the extension from Euston to Camden Town is just under a mile. In this the stiffest gradient against the traffic is 1 in 40, and 1 in 30 in the direction of travel. Six Greathead shields were used in the work, which occupied a period of only seventeen months.

Electrical signalling is in use and the new lines are track-circuited throughout. A frame of 43 levers, 37 of which are operative, was supplied by the Westinghouse Brake and Saxby Signal Company, Limited, and erected by the staff of the Underground Company in a signal box, situated at the end of the north-bound platform at Camden Town. The equipment is provided with an illuminated diagram to indicate to the signalman the traffic condition of the line within his jurisdiction, and separate indicators warn him of the destinations of each train approaching the station. The plans for the extensions were prepared by the consulting engineer of the Underground Electric Railways, Mr. H. H. Dalrymple Hay, and Messrs. John Mowlem and Co., Limited, were the contractors, but all work involved in laying the permanent way, the conductor rails, cables and signals was carried out by the company's own staff.

The Camden Town extension is the important junction or connection link of the two systems, but in addition, the gigantic task had to be contemplated of widening the many miles of tube of the City and South London Railway. This, as has already been stated, has been partly finished (the length from Euston to Moorgate) and is now in use. Work is fast approaching completion in the southern section to Clapham. In this work the consulting engineers for the widening, Messrs. Mott, Hay and Anderson, adopted a method of working in which the segments of the old iron casing were made use of and the extended diameter was obtained by the insertion of key pieces. Each ring of casing as it was removed was built in place in the widened section, and after bolting up, cement grouting was introduced through holes in the segments to give solid and effective backing. With this way of working the width of only two rings was left unsupported at any time between the original and the widened tube. After completion, caulked joints were made between the rings with iron filings and sal-ammoniac and the whole tube became a solid structure. Many station improvements have been made in the course of the work, not only in lengthening the platforms, but in widening them, and by the provision of better facilities for the transport of passengers between the levels of the streets and the platforms. Because of this linking up at Camden Town and the widening of the old tubes, passengers can now travel through from the heart of the City to Hendon, Golders Green and Highgate without changing, and thus with a great saving in time.

The new rolling stock embodies the principal features of the six experimental cars built in 1922, and a total of 81 motor cars, 35 control trailer cars and 75 ordinary trailer cars have been ordered for the system. Their construction was divided between three firms—Messrs. Cammell Laird and Co., Limited, of Nottingham, the Metropolitan Carriage Wagon and Finance Company, of Birmingham, and the Birmingham Railway Carriage and Wagon Company, of Smethwick. The overall length of each car is 49 ft. 9½ in., the width is 8 ft. 6¾ in., and the overall height from the running rail is 9 ft. 6 in. The motor cars will seat 30 passengers, the control trailers 44 and the ordinary trailers 48. The unladen weight of the motor cars is 31 tons, while the trailer cars scale 17¾ tons.

CATALOGUES.

Fan.—British Insulated and Helsby Cables, Limited, Prescot, Lancs, have issued a new edition of their catalogue of electric ceiling fans, giving particulars of construction and current consumption.

Temperature Measurement.—Messrs. Siemens Brothers and Co., Limited, Woolwich, have sent us a catalogue of temperature measuring instruments describing several different types of pyrometers, &c., and their accessories.

Puddled Iron.—The Albert Iron and Steel Company, Limited, West Bromwich, have issued a small pamphlet containing an interesting description of the old process of puddled iron manufacture together with some notes on the corrosion-resisting qualities of iron. The firm supply puddled iron in the form of sheets, tubes, fittings, and the usual bars and sections.

Refrigerating Machinery.—A general specification with illustrations of a series of ammonia compressors for belt driving, and a booklet relating to marine refrigerating machinery, made by the Brunswick-Kroeschell Company and the Brunswick Refrigerating Company respectively, have come to hand from their agent in this country, Mr. A. H. Goldingham, 53, Victoria-street, London, S.W. 1.

Oil Engines.—We have received several interesting catalogues illustrating installations of Diesel and other heavy oil engines, refrigerating plant, &c., carried out by the De La Vergne Machine Company, New York, U.S.A., from their agent in this country, Mr. A. H. Goldingham, 53, Victoria-street, London, S.W. 1. Another catalogue from the same source illustrates and describes an oil reclaimer for purifying lubricating oil after use in internal-combustion engines.

Turbo-Generators.—A new edition of their turbo-generator catalogue issued by the Brush Electrical Engineering Company, Limited, Loughborough, is of great technical and practical interest. It contains a full description of construction of these machines, with separate illustrations of the principal parts and, in some cases, describes the methods of manufacture. Particulars relating to erection, dismantling, &c., are given, as well as a table and graphs of data obtained from a six-hour trial of a 5,000 kw. set. The catalogue is carefully compiled and well produced, and will be welcomed by all engineers interested in power station work.

Locomotives.—Over 80 locomotives are illustrated in the new edition of their general catalogue recently issued by Messrs. Andrew Barclay, Sons and Co., Limited, Kilmarnock. The catalogue covers a full range of types for all classes of work, and for burning coal, wood or oil as fuel. A table of dimensions and capacities is given for each type, most of which are suitable for use in steel works, collieries, quarries, &c., or for colonial estate and general contractors' work. Among the special types dealt with are crane locomotives, articulated locomotives and "fireless" engines. The use of the latter, it may be remarked, is not now confined to situations where there is a serious danger from fire. Engines of this class can be charged with sufficient steam and hot water in about 20 minutes to enable them to be used for about four hours on shunting work. The catalogue includes illustrations of a small shunting locomotive which is still in use after 70 years service.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

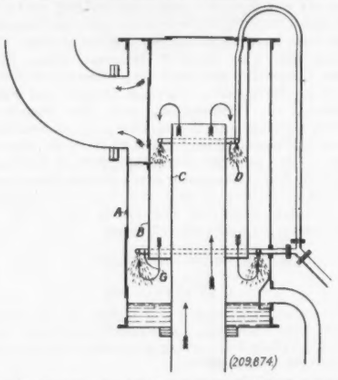
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

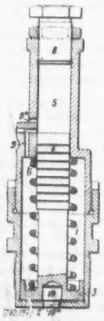
GAS ENGINES, PRODUCERS, HOLDERS, &c.

209,874. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne, and G. Scott, Newcastle-on-Tyne. Exhaust Expansion Chambers. (2 *Figs.*) November 2, 1922.—The invention relates to exhaust expansion chambers for internal combustion engines. According to the invention, the means for silencing and cooling the exhaust gases of an internal combustion engine comprises an expansion chamber A having a cylinder B extending downwardly from the top of the chamber near to the other end, an inlet pipe C passing through the bottom



of the chamber A and extending upwards within the cylinder B, a water spray D surrounding the pipe C near its upper end and adapted to cool the gases where they change their direction and quench any sparks, and a second water spray G surrounding the cylinder B at or near the bottom and adapted further to cool the gases where they change their direction a second time. Preferably also the chamber A is provided with a water sump over the surface of which the exhaust gases pass before issuing to the atmosphere, and into which any carbon particles fall. (*Sealed.*)

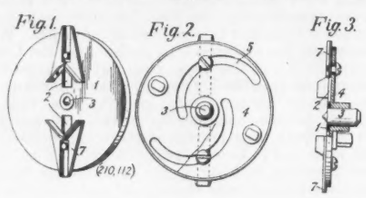
210,197. T. A. Evans, Cheetham Hill, Manchester. Internal Combustion Engines. (1 *Fig.*) November 9, 1922.—The object of the invention is to provide means whereby the degree of compression of the charge of explosive mixture may be reduced when the engine is working at a low speed without affecting in the same proportion the degree of compression at high speed. For the purpose of the invention it is proposed to provide a small chamber which may be attached to or form an integral part of the cylinder-head and is adapted to communicate with the compression space by means of an opening of suitable size and shape. A device constructed according to the invention is adapted to replace one of the valve caps as ordinarily fitted to the cylinder of an internal-combustion engine. 1 is a small cylinder which is attached to the cylinder-head and communicates with the compression space of the cylinder by means of an opening 2. 3 is a piston adapted to reciprocate within the cylinder 1, the piston 3 being provided with a piston



rod 4 which works in a chamber 5. The piston 3 is controlled by a spring 6. The top of the chamber 5 is provided with a plug 8, which permits the volume of the chamber 5 to be adjusted as desired. Small passages 9 and 9*a* are furnished in order to normalise the pressures in the cylinder 1 and chamber 5 when the piston is at the bottom of its stroke, so as to compensate for any leakages which may occur and for pressures set up by variations in temperature, and the arrangement is such that both of the passages 9 and 9*a* are covered by the piston 3 as it rises. When the passages 9 and 9*a* are covered, the further movement of the piston 3 will be checked or controlled by the air cushions in the cylinder 1 and chamber 5. The piston 3 is provided with a tapped hole in which is screwed a plug 10, which is furnished with an extension 10*a* adapted to enter the opening 2 and restrict the same in such manner as to form an annular orifice around the extension 10*a*. In operation, when a large charge is drawn into the cylinder by the induction stroke of the engine and the gases are compressed by the compression stroke, the gases enter the orifice 2 and act upon the whole area of the underside of the piston 3, which pressure causes the piston 3 to rise against the pressure of the spring 6 and the air cushion in the cylinder 1 and chamber 5 in such manner that by the time the charge is fired the compression thereof has been appreciably reduced. After the explosion of the charge and the consequent fall of the engine piston in the cylinder, the piston 3 is constrained by the spring 6 and the pressure of the air cushions in the cylinder 1 and chamber 5 to fall into its normal position. As the piston 3 returns to its original position it performs the function of scouring out the gases from the cylinder 1, and the completion of its return is arrested by reason of a small quantity of the gases being trapped in the cylinder 1 when the extension or plug 10*a* enters the orifice 2, the trapped gases finally escaping through the annular space between the extension 10*a* and the opening 2. (*Accepted February* 6, 1924.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

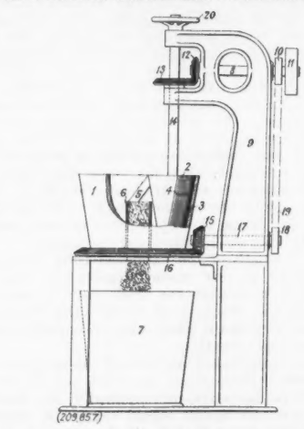
210,112. D. Ward, Winson Green, Birmingham. Centre Marking Device. (3 *Figs.*) September 18, 1922. The invention relates to a device for finding the centres of the end faces of rods or other members. A centring device, according to the invention, comprises two relatively movable discs 1, 4—one, 4, of which is provided with a number of spiral slots 5, and the other, 1, with a corresponding number of radially disposed slots 2; 7 are locating devices to engage the member to be centered,



each engaging both with a spiral slot 4 and with a radially disposed slot 1, whereby the relative movement of the two discs 1, 4 moves the locating members 7 uniformly and simultaneously towards a centre, so that in every possible position the locating members are equally distant from the centre. 3 is a hole to receive a marking device, or a marking device is located in the centre of the discs whereby the centre can be marked. (*Accepted February* 6, 1924.)

MILLING AND SEPARATING MACHINES.

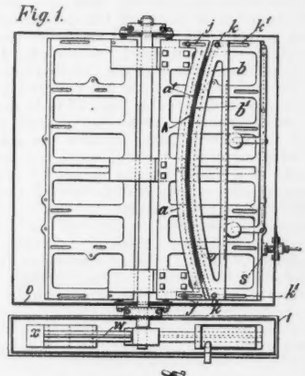
209,857. C. J. Seaman, Poplar, London, and Brinjes and Goodwin, Limited, Poplar, London. Grinding, Crushing and Mixing Mills. (3 *Figs.*) October 24, 1922.—The invention relates to grinding, crushing, mixing and like mills. According to the invention, the material is treated between two contacting truncated conical members which are both of the same conicity and each of which is positively driven, the truncated conical members having their major diameters in contact and their minor diameters in contact, so that in operation the material is automatically advanced from the minor diametral ends to the major diametral ends of the truncated conical members. The mill comprises two truncated conical members 1, 2 which are arranged one inside the other, the grinding, crushing, mixing and/or like operation being effected between the peripheral co-operating surfaces 3, 4 of the truncated conical members so that during working the material being treated moves up or along the peripheral surface of the inner truncated conical member 2 and is removed by a scraper 5 at the upper end thereof. The material then passes through a centrally arranged tube 6 into a collector 7. The outer truncated conical member 1 is made in the form of a



receptacle and the inner truncated conical member 2, which may be in the form of a solid or hollow member, is arranged inside the receptacle 1 in such position that the surfaces of the two truncated conical members co-operate to effect the desired result. The inner truncated conical member is rotated from the main shaft 8, which is suitably supported in a frame 9, the shaft 9 being provided with two pulleys 10, 11 and a bevel gear wheel 12. The bevel gear wheel 12 drives a bevel gear wheel 13 which is rigidly mounted on the shaft 14 carrying the truncated conical member 2. The outer truncated conical member is rotated by gearing 15, 16, the bevel gear wheel 15 being mounted on a shaft 17 provided with a pulley 18 which is driven by a belt 19 or other suitable means from the pulley 10. The pressure between the two truncated conical members, namely, the receptacle 1 and the inner rotatable truncated conical member 2, may be varied by vertical adjustment by means of a hand wheel 20, the rotation of which effects longitudinal displacement of the inner truncated conical member 2; or the adjustment may be effected by lateral displacement of the receptacle 1 containing the material to be treated. (*Sealed.*)

MOTOR ROAD VEHICLES.

210,473. Sir R. A. Hadfield, Westminster, London, and A. B. H. Clerke, Sheffield. Laminated Springs. (6 *Figs.*) August 29, 1922.—The invention has reference to apparatus for use in the manufacture of spring blades or leaves for laminated springs. *a* and *b* are two dies, constituting a pair, the adjacent working faces *a*1 and *b*1 of which are formed to the camber which it is desired should be imparted to the spring leaf. A number of pairs of dies is mounted on movable rotary carriers *i*, one die, *a*, being fixed to its carrier by a pin-and-slot connection *j*, whilst the other die, *b*, is arranged to move parallel to itself by pins *k* extending into parallel slots *k*1 in its carrier *i*. The die can be moved back freely when released, but is forced quickly toward the die *a* by lever mechanism. Each carrier *i* is fixed radially to spiders *n*1 fixed to a horizontal rotary shaft *n* extending across the open top of a tank *o* charged with quenching liquid *r*, so that by rotating the shaft after a heated strip A of spring steel has been inserted between the pair of dies carried by the frame and pressed to the desired curvature or camber, the pair of dies with strip of steel can at once be immersed in the quenching liquid to harden the strip. To admit of strips of heated steel being pressed to shape in a quick and methodical manner, the shaft *n* is provided with a number of radial carriers *i* with pairs of dies *a*, *b*, say for example five, spaced at equal angular distances apart. A catch is provided on the tank *o* to secure each frame in turn in a horizontal position and immediately above the surface of the quenching liquid. The catch comprises a slide *s* adapted to be moved automatically by a spring into a position below each carrier in turn, to support the latter in the horizontal position. Means are provided by which



the shaft *n* with its carriers *i* can be rotated intermittently and automatically to bring each frame in turn to the horizontal position in which it is held by the catch *s*, and in which position a leaf can be inserted between the pair of dies *a* and *b* and bent to shape, ready to be immersed in the cooling liquid, with the least possible loss of time, upon the release of the catch. Suitable means comprise a number of spokes *w* attached to one end of the shaft *n*, each spoke carrying a receptacle *x* so arranged that one or other of them will always lie in a horizontal position when one of the carriers *i* with its pair of dies is in the horizontal position located by the catch *s*. The spokes with their receptacles are arranged within a separate tank 1 provided with an exhaust pipe 2, from which a continuously running pump delivers water through an inlet pipe 3 into the open top of the receptacle *x* that is, for the time being, held in a horizontal position. A sufficient supply of water for this purpose is allowed to remain in the tank. On the withdrawal of the catch *s* from the carrier *i* with which it was last engaged, the weight of the charged receptacle *x* will cause the shaft *n* to rotate one stage, bringing the next following frame with pair of dies to the position located by the catch. In so doing, the receptacle *x* will empty itself on reaching the lower portion of the tank, while the next following receptacle will come to rest in position, in which it will rapidly be charged with water by the action of the pump, ready for effecting the next partial rotation of the shaft and frames with dies. (*Accepted February* 6, 1924.)

AMERICAN STEEL RAIL PRODUCTION.—Statistics issued by the American Iron and Steel Institute show that the steel rail production in the United States in 1923 reached a total of 2,904,516 gross tons, 33·74 per cent. over the total which was reached during 1922.